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PROJECT

Contemporary
Historical
Evaluation of
Combat
Operations
REPORT

Tactical Electronic Warfare Operations in SEA, 1962-1968

10 February 1969

HQ PACAF

**Directorate, Tactical Evaluation
CHECO Division**

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Project CHECO 7th AF, DOAC

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PROJECT CHECO REPORTS

The counterinsurgency and unconventional warfare environment of Southeast Asia has resulted in the employment of USAF airpower to meet a multitude of requirements. The varied applications of airpower have involved the full spectrum of USAF aerospace vehicles, support equipment, and manpower. As a result, there has been an accumulation of operational data and experiences that, as a priority, must be collected, documented, and analyzed as to current and future impact upon USAF policies, concepts, and doctrine.

Fortunately, the value of collecting and documenting our SEA experiences was recognized at an early date. In 1962, Hq USAF directed CINCPACAF to establish an activity that would be primarily responsive to Air Staff requirements and direction, and would provide timely and analytical studies of USAF combat operations in SEA.

Project CHECO, an acronym for Contemporary Historical Evaluation of Combat Operations, was established to meet this Air Staff requirement. Managed by Hq PACAF, with elements at Hq 7AF and 7/13AF, Project CHECO provides a scholarly, "on-going" historical evaluation and documentation of USAF policies, concepts, and doctrine in Southeast Asia combat operations. This CHECO report is part of the overall documentation and evaluation which is being accomplished. Along with the other CHECO publications, this is an authentic source for an assessment of the effectiveness of USAF airpower in SEA.



MILTON B. ADAMS, Major General, USAF
Chief of Staff

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FOR THE COMMANDER IN CHIEF

Warren H. Peterson
WARREN H. PETERSON, Colonel, USAF
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(14)	AFXPD	6

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(c)	DOTS	1
(d)	DORQ	1
(e)	DI	1

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(b) 12AF

<u>1</u>	DO.	1
<u>2</u>	DP.	1
<u>3</u>	DI.	1

(c) 19AF

<u>1</u>	DO.	1
<u>2</u>	DP.	1
<u>3</u>	DA-C.	1

(d) USAFSOF

<u>1</u>	DO.	2
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(3) AIR DIVISIONS

(a)	831AD.	2
(b)	832AD.	2
(c)	833AD.	2
(d)	835AD.	2
(e)	836AD.	2
(f)	838AD.	2
(g)	839AD.	2
(h)	840AD.	2

(4) WINGS

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(c)	15TFW.	1
(d)	23TFW.	1
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(f)	33TFW.	1
(g)	49TFW.	1
(h)	64TFW.	1
(i)	67TFW.	1
(j)	75TFW.	1
(k)	78FW	1
(l)	82CSPW	1
(m)	113TFW	1
(n)	123TRW	1
(o)	140TFW	1
(p)	313TAW	1
(q)	316TAW	1
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(u)	474TFW	1

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(v) 479TFW. 1
(w) 516TAW. 1
(x) 4410CCTW. 1
(y) 4442CCTW. 1
(z) 4453CCTW. 1
(aa) 4500ABW. 1
(bb) 4510CCTW. 1
(cc) 4525FWW. 1
(dd) 4531TFW. 1

(5) TAC CENTERS, SCHOOLS

(a) USAFTAWC
 1 DA 2
(b) USAFTARC
 1 DI 2
(c) USAF TALC
 1 DA 2
(d) USAF TFWC
 1 CRCD 2
(e) USAFSOC 2
(f) USAFAGOS. 2

b. SAC

(1) HEADQUARTERS

(a) DO 1
(b) DPL 1
(c) DM 1
(d) DI 1

(2) AIR FORCES

(a) 2AF 1
(b) 8AF 1
(c) 15AF 1

(3) AIR DIVISIONS

(a) 3AD 3

c. MAC

(1) HEADQUARTERS

(a) MAOID 1
(b) MAOCO 1
(c) MAFOI 1
(d) MACOA 1

(2) AIR FORCES

(a) 21AF
 1 ODC. 1
 2 OCXI 1
(b) 22AF
 1 ODC. 1
 2 OCXI 1

(3) AIR DIVISIONS

(a) 322AD 1

(4) WINGS

(a) 375 AAWG
 1 ODC. 1
(b) 89 MAWG
 1 ODC. 1
(c) 60 MAWG
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(g) 435 MAWG <u>1</u> ODC. 1 <u>2</u> OTI. 1	(d) AAVS <u>1</u> AVODC. 1
(h) 436 MAWG <u>1</u> ODC. 1 <u>2</u> OX 1	d. ADC
(i) 437 MAWG <u>1</u> ODC. 1 <u>2</u> OXI. 1	(1) HEADQUARTERS (a) ADODC 1 (b) ADOOP 1 (c) ADOTT 1 (d) ADLPP 1
(j) 438 MAWG <u>1</u> ODC. 1 <u>2</u> OX 1	(2) AIR FORCES (a) 1AF <u>1</u> DO 1 <u>2</u> DP 1
(k) 445 MAWG <u>1</u> ODC. 1 <u>2</u> WDO-PLI. . . . 1	(b) 4AF <u>1</u> DO 1 <u>2</u> DP 1 (c) 10AF
(5) MAC SERVICES (a) AWS <u>1</u> AWODC. 1 <u>2</u> AFCSPI 1	<u>1</u> DO 1 <u>2</u> DP 1 (d) 14Aerosp Force. . 2 (e) AF Iceland. 2
(b) ARRS <u>1</u> ARODC. 1	(3) AIR DIVISIONS (a) 25AD. 2 (b) 26AD. 2 (c) 27AD. 2

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(d) 28AD. 2
 (e) 29AD. 2
 (f) 31AD. 2
 (g) 32AD. 2
 (h) 33AD. 2
 (i) 34AD. 2
 (j) 35AD. 2
 (k) 36AD. 2
 (l) 37AD. 2

e. ATC

(1) HEADQUARTERS

(a) ATXDC 1

f. AFLC

(1) HEADQUARTERS

(a) MCFS. 1
 (b) MCKH. 1
 (c) MCOO. 1

g. AFSC

(1) HEADQUARTERS

(a) SCLA. 2
 (b) SCS-6 1
 (c) SCTPL 1
 (d) SCEH. 2
 (e) ASD/ASJP. 2
 (f) ESD/ESWV. 2
 (g) ADTC/ADP. 2
 (h) RADC/EMOEL. 2

h. AFCS

(1) HEADQUARTERS

(a) CSOCH 5

i. USAFSS

(1) HEADQUARTERS

(a) ODC 1
 (b) CHO 5

(2) SUBORDINATE UNITS

(a) Eur Scty Rgn

1 OPD. 1

(b) 6940 Scty Wg

1 OOD. 1

j. AAC

(1) HEADQUARTERS

(a) ALDOC 2

k. USAFSO

(1) BIOH 1
 (2) OOP. 1

1. PACAF

(1) HEADQUARTERS

(a) DP. 1
 (b) DI. 1
 (c) DO. 1
 (d) DPL. 4
 (e) DXIH. 1
 (f) DOTEK. 6
 (g) DE. 1
 (h) DM. 1

(2) AIR FORCES

(a) 5AF

1 DOPP 1
2 DP. 1

(b) 7AF

1 DO 1
2 DI 1
3 DPL. 1
4 TACC 1
5 DOAC 2

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(c)	13AF	
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(d)	7AF/13AF	
	<u>1</u>	CHECO. . . . 3
(3)	AIR DIVISIONS	
(a)	313 Air Div	
	<u>1</u>	DOP. 2
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(d)	834AD	2
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(b)	8TFW.	1
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(d)	14SOW	1
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(r)	483TAW.	1
(s)	553RW	1
(t)	633SOW.	1
(u)	6400Test Sq . . .	1

(5)	OTHER UNITS	
(a)	Task Force ALPHA .	1
(b)	504TASG.	1
m.	USAFE	
(1)	HEADQUARTERS	
(a)	ODC/OA	1
(b)	ODC/OTA.	1
(c)	ODC/OOT.	1
(d)	XDC.	1
(2)	AIR FORCES	
(a)	3AF.	2
(b)	16AF	2
(c)	17AF	2
(3)	WINGS	
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(b)	20TFW.	1
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(h)	81TFW.	1
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(j)	401TFW	1
(k)	513TAW	1
(l)	601TCW	1
(m)	7101ABW.	1
(n)	7149TFW.	1
(o)	7272FTW.	1

4. SEPARATE OPERATING AGENCIES

a.	AFAFC.	1
b.	AFDSDC	2
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FOREWORD

This report describes the evolution of Tactical Electronic Warfare (TEW) operations in Southeast Asia from 1962 to 1968. It addresses the technological or mechanical aspects of electronics equipment only if necessary to clarify tactical air operations. Sensitivity of various electronic activities in SEA limited accessibility to certain types of information. "Tactical Electronic Warfare Operations in SEA" blends together all activities which were a part of the framework of TEW operations in that area. The last chapter summarizes and assesses several significant developments in these operations.

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CHAPTER I

INTRODUCTION

(Part I: Jan 62 - Jun 65)

Electronic Warfare Historical Survey

Compared to many facets of military history, the history of electronic warfare (EW) is a relatively short one. It took shape only when electronic equipment was employed to change the outcome of military operations. Interception of Russian messages containing the tactical plans of their field forces contributed to the German victory at the Battle of Tannenberg in 1914. On another occasion during World War I, "the British by decoy radio messages caused a German zeppelin en route to Africa (with an important cargo of Generals) to return to Germany--presumably to the consternation of the Germans and the delight of the British."^{1/}

As a result of his experience commanding the expeditionary force, which pursued Pancho Villa into Mexico in 1916, and with the questionable performance of the First Aero Squadron in helping pin down the bandit, Gen. John J. Pershing was convinced that "an army without tactical air reconnaissance 'is doomed to failure against one with it."^{2/}

World War II

Electronic warfare really came into its own as an important

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element in warfare during World War II with the introduction of radar. Quite appropriately, warfare in the electronic medium was called the "Battle of the Beams." The German bombing campaign over Britain and the Allied bombing effort over Europe lent themselves to a constantly shifting electronic interplay as one side strove to counter or get an edge on the other. Sir Winston Churchill eventually labeled this seesaw battle, the "Wizard War" or "Battle of the Wizards." In a related area, the Germans successfully employed radio direction finding equipment to track down partisan forces throughout occupied Europe.^{3/}

The "Battle of the Beams" during World War II provided much experience and valuable lessons. However, electronic warfare was certainly not a necessary condition of victory, as is true in this era. German radar systems were very good and were used for early warning, fire control, and searchlight direction. The Allies countered what constituted a major flak threat by emitting a "carpet of electronically generated noise" or "active jamming" and by sowing "clouds of reflecting material" or chaff. (The Japanese were also using radar but their systems posed no serious threat.) Each side worked frantically to parry the other's moves--with the ultimate edge going to the Allies. (Appendix I.) Many of the techniques that are regarded today as sophisticated were attempted or proposed during the war--or thereafter. The valuable experiences gained should have presaged a bright future for electronic warfare, but too many of the lessons were forgotten and too few inroads were made against the limiting technology. In a very apt simile, it has been said that electronic warfare "is like

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medicine" in that "a normally negligible interest in either heightens remarkably in a crisis."^{4/}

Post World War II and Korea

In the late 1940s, "EW died--or at least sank into a comatose state...." The subsequent history showed "a sequence of relapses and injections." Some injections were U.S. initiated; others were traceable to outside sources, such as reactions to an enemy's air defenses, missiles, etc. It has also been suggested that a previous commitment to strategic nuclear problems caused a focus on strategic problems at the expense of tactical problems, and that military leaders overestimated the protection afforded aircraft by flying low and underestimated the difficulty in locating targets while at low altitude. War in Korea revived somewhat the faint spark of life that remained in some "die-hard" EW quarters.^{5/}

When the Korean conflict began, only a meager amount of AAA was deployed in North Korea, and the units were very poorly equipped. From these modest beginnings, however, the defenses against air attack expanded to include 25 early warning and 11 GCI radars, 720 guns, and 922 automatic weapons by the time hostilities ended. These were employed primarily to protect targets in the northwest, but the defenses were considered incapable of denying U.S. access to the target areas. The network included early warning/GCI, gun-laying, and extensive searchlight control radars. However, AAA defenses were weak when judged against World War II standards.^{6/}

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Combat losses in World War II were reduced by an estimated 25 percent through application of electronic countermeasures (ECM). This was the lesson apparently lost during the doldrums of the late 1940s, and for a time the lesson remained lost, due to the negligible North Korean flak and radar capabilities during the first year and a half of that war, although some ECM revitalization had begun when hostilities commenced. A requirement for ECM increased as North Korean defenses improved. U.S. bombers first attempted electronic jamming on 10 April 1951. The value of ECM was demonstrated on the night of 10-11 June 1952, when B-29s bombed the railway bridge at Kwaksan; one aircraft, the last one over the target, used ECM and it was the only one to escape illumination by searchlights. Chaff was first dropped on a raid against the Sui-ho power plant on 12 September 1952.^{7/} By the spring of 1953, a great deal of effort had been expended to protect medium bombers against night defenses.

The greatest threat to the bombers seemed to come from enemy searchlights, once it was obvious that B-29s could not survive in daylight and were shifted to night operations. Improved Communist defenses caused a crisis by mid-1952. Resort to searchlight suppression produced mixed results at best. In retrospect, the failure of suppression alone emphasized the futility of concentrating on one system, or one part of it.^{8/} Eventually, only a "razzle dazzle" combination of tactics provided the solution--an attack on the whole North Korean air defense system through integration of every conceivably useful tactic. After January 1953, North Korean air defenses were substantially negated by irregularly scheduled attacks, compression of the bomber stream, multiple approaches to the target, avoidance

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of contrail altitudes and moonlit nights, camouflage, fighter CAP, and application of ECM against gun-laying and searchlight control radars.^{9/}

Basically, tactical employment of ECM sought to provide the required degree of jamming protection, while avoiding disclosure of U.S. capabilities. First priority was assigned to the searchlight control radar/fighter combination; second priority went to gun-laying radars when the searchlight/fighter threat was absent; last priority was given to GCI/HF radars. Policy called for the use of ECM "only against immediate threats" and "no attempt was made to jam early warning radars." Partial jamming of HF GCI communications was employed on strikes along the Yalu; complete jamming was avoided to prevent compromise of advanced U.S. techniques, "but mainly because of the priority assigned to intelligence functions monitoring these nets."^{10/} Bombers were screened over sensitive targets by continuous chaff drops.

Resolution of the mid-1952 crisis was not accomplished without solving a concomitant array of provocative problems. Integration of all the tactics previously mentioned did not take place overnight--but rather within a time frame of seven to eight months. Much of the ECM equipment was of World War II vintage. Chaff effectiveness was impaired by dispenser malfunctions and deteriorated tapes. Equipment was in short supply. Qualified ECM officers were very scarce, and the training of highly qualified enlisted ECM operators for B-29 crews "proved an all but impossible problem." This sparsity of trained talent affected the skillful application of ECM. An effort to locate enemy radars with airborne direction finding equipment carried in B-26s, and tests of B-26 HUNTER-KILLER operations against them, were noteworthy for the

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meager results achieved. These efforts either ran into never-ending problems or triggered differing and unresolved debates over concepts of operation--or simply failed completely.^{11/}

Any ECM balance sheet for the Korean conflict must weigh the debits against the credits. Without ECM, it was thought that combat losses would have been much higher. Yet, the ECM applied was reactive to North Korean defensive ascendancy. Years of neglect forced the use of inadequate equipment by variably qualified personnel, who worked diligently under the circumstances to provide U.S. aircraft with an ECM edge as the conflict drew to a close. Commanders, staffs, and crews were reeducated in the value and application of ECM. Yet, Korean War ECM techniques were not new; the old lessons were revived. Viewed in a global context, USAF was concerned about disclosing its ECM capabilities by active employment, while simultaneously resorting to jamming "when absolutely necessary" and "only in current and anticipated operations."^{12/}

This brief survey of TEW history was presented to provide a perspective for the subsequent analysis of electronic warfare developments. More meaningful insights can be extrapolated from operations in SEA when projected against the background of USAF ECM activities over North Korea. Between the close of the Korean conflict and the substantial introduction of U.S. military power into SEA in late 1964, the sense of urgency associated with tactical ECM in mid-1953 was again on the wane. Some would argue that the lessons were apparently forgotten. However, during the same period, an effort was made to clarify and to define the scope and parameters of TEW.

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Definitions of Terms

At one time electronic warfare (EW) embraced the use of electronic instruments in radio communications, guided missile control, and target detection. Later, it included the following military uses: communications, radar, infrared, navigation, missile guidance, electronic countermeasures, and electronic counter-countermeasures (ECCM). Since the 1940s, military use of electronic radiating equipment increased to vast proportions. This inevitably led to a modification of the previously defined parameters of EW. By 1964, it was defined as "that division of the 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." The definition logically included two major subdivisions--ECM and ECCM.^{13/}

In the context of TEW, 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.

ECM sought "to prevent or reduce the effectiveness of enemy equipment, weapons, and those tactics employing or affected by electromagnetic radiations." On the other hand, ECCM sought "to insure our own effective use of electromagnetic radiations in spite of the enemy's use of countermeasures." Communications intelligence (COMINT) and electronic intelligence (ELINT) were activities oriented to strategic applications; however, the obvious

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support, coordination, and exchange between COMINT/ELINT and ECM activities were deemed essential. Nevertheless, COMINT/ELINT, strictly speaking, did not fall within the purview of TEW; policy governing its activities was separate from that established for EW.^{14/}

EW policy for the military services was determined at the highest level by the JCS. Command responsibility for EW activities was vested in commanders of unified and specified commands, where applicable. The CSAF was also responsible for Air Force implementation of JCS electronic warfare policy. One aspect of this responsibility was particularly applicable to TEW operations in SEA, because CSAF provided "service support to EW operations of the commanders of unified and specified commands."^{15/}

The scope of ECM was further divided into passive ECM (PECM) and active ECM (AECM). PECM embraced the "conduct of search, intercept, direction finding, range estimation, and signal analysis of communications and noncommunications electronic radiations to permit immediate operational use of the information."^{16/} The definition was exceptionally broad; it had the potential to justify and to include a wide variety of activities that were not specifically spelled out. By comparison, AECM had tighter reins drawn around it, to include only deliberate jamming and deception. (In 1963, evasion and destruction were considered to be elements of AECM; presently, ECM activity specifically excludes "actions taken to physically capture or destroy enemy electromagnetic radiating equipments."^{17/} Jamming used radiation, reradiation, or reflection to counter enemy

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devices. Deception used these, plus alteration and absorption, to mislead an enemy in the interpretation of signals received or to present false indications.^{18/} In summary, ECM employing deliberate jamming or deception was considered active; all other ECM activity was viewed as passive. This distinction was clearly presented in operational doctrine.

ECM Operational Doctrine

While no Air Force manual treated ECCM operational doctrine, AFM 2-8 (14 Jan 66) provided ECM doctrine for tactical air warfare. Two major factors considered necessary for the success of tactical air operations were: (1) exploitation of enemy radar weaknesses; and (2) determination of the vulnerability of electronics in military operations by technical and tactical methods. Thus, the ultimate aim of ECM was "to assist in protecting tactical air forces against counter air weapons by defeating or degrading enemy electronic detection and weapons directing and guidance systems" through application of PECM and AECM.^{19/} Any application of ECM presupposed that all other measures commensurate with mission requirements were taken concurrently. These included: (1) avoidance of enemy defensive systems; (2) exploitation of inherent weaknesses in the equipment of a defense complex; (3) exploitation of inherent offensive systems capability; and (4) use of surprise.^{20/}

PECM operations were to be "performed in direct and immediate support of air operations under way and conducted for other than strategic intelligence purposes." They were oriented to information collection which had an immediate and significant impact on the conduct of tactical air

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operations. This was true even when the equipment used might have been identical to that used for COMINT/ELINT activities--the key being whether such equipment supported an operational mission or objective.^{21/} Operational doctrine envisioned that PECM and its support actions could provide the following: (1) immediate warning and operations information to strike aircraft when enemy radar activity was first initiated to enable evasive tactics against missile or radar controlled AAA attack; (2) real-time information during HUNTER-KILLER type of operations; (3) partial determination of the effectiveness of active ECM in the area by detecting the on and off modes of the threat or defense radars; (4) guidance of strike aircraft away from radar controlled defenses; and (5) assistance to strike aircraft for weapons delivery. The product of electronic intercept and direction finding activity was to be used initially as an aid to counter the adversary, and secondly in priority, to provide inputs to intelligence updating.^{22/}

AECM in tactical operations envisioned mutual screening by ECM support aircraft and/or self-screening of tactical aircraft through use of external pods or internal equipment to "deny or delay acquisition and engagement of penetrating aircraft by enemy defensive systems." This type of ECM effort was to be directed against an area threat and a terminal threat. The former threat was posed by surveillance, long-range acquisition, and GCI radars; it was to be attacked with noise jammers, deception jammers, decoys, and chaff. The latter threat was posed by gun-laying and target-missile tracking radars; it was attacked with similar equipment.^{23/}

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In summary, U.S. Air Force operational TEW doctrine presupposed that several measures be taken to reduce strike force exposure time. It stressed the importance of mutual support among ECM and COMINT/ELINT activities. Both PECM and AECM were considered necessary to insure mission success with minimum losses. Finally, these additional, special considerations in tactical ECM were emphasized: (1) ECM harassment to rob an enemy of alertness and a sense of urgency by inducing complacency and fatigue; (2) looking at the contest as one of man versus man, as well as jammer versus radar; and (3) close coordination between ECM planners and strike planners for operations against an overall defensive environment and not against a specific system.^{24/}

Few, if any, parameters escaped consideration in defining and clarifying the ECM doctrine for tactical air warfare in the conduct of tactical airstrikes. However, AFM 2-8 was almost exclusively oriented to airstrike operations. This point is made only to alert the reader that airborne radio direction finding (ARDF) was not specifically identified and covered in detail within the context of tactical ECM operations; yet, it was very much a part of the SEA TEW picture. The best operational parallel to ARDF appeared in another manual.

TAR Versus ECM Doctrine

A comparison of Tactical Air Reconnaissance (TAR) and ECM operational doctrine suggested that inclusion of ARDF activity might be implied from the terminology used in both. When considered in the light of ARDF operations in SEA, neither manual, by itself, seemed to provide an exclusive doctrinal base--neither formalized ARDF activity by name. The clearest

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general definition of it was found in AFR 55-90 and the ECM doctrinal manual--as a type of PECM. However, the closest description of how ARDF operations were conducted in SEA was found in the TAR manual. In the theater, ARDF operations were considered as PECM. Doctrinal formalization aside, the main concern was to get the job done, but future formalization will undoubtedly be an important consideration.

Scrutiny of current USAF operational doctrine for tactical air reconnaissance revealed that the role of ARDF, as performed in SEA, was not specifically formalized in that area. In discussing reconnaissance support, employment, organization, and command/control, however, nearly every type of data provided by ARDF TEW Squadrons in SEA was mentioned, without spelling out that these be accomplished with special ARDF aircraft. The terminology employed to explain reconnaissance doctrine was flexible enough to embrace the ARDF concept.

There were numerous illustrations of this. Forces deployed for this purpose were to support the need for accurate information on enemy "structure movement, strength, disposition, capability." When unified commanders delineated the essential information required, the responsible air commander was to establish operational priorities. In a close support role the air commander, through the TACS, was required to provide continuous information to prevent the enemy from producing disastrous ground military surprises as well as to maintain continuous and current knowledge of his actions and capabilities. Organization of TAR forces was to be "tailored to the needs of, and responsible to the joint force and component commanders." The

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"location, strength, and disposition of enemy ground forces" were primary tasks for TAR forces "operating over the field of battle." When types of transient and fleeting targets were discussed, these included "camps, troop concentrations, supply concentrations, electronic emitters," and other objects which move--such as troops in transit.^{25/}

Some time was taken to explore the theoretical/doctrinal base for ARDF operations primarily because it was difficult to categorically establish which operational doctrine, TAR, or ECM, provided the framework for ARDF activity. Research seemed to suggest that the operations in SEA were not guided exclusively by one or the other.^{26/} This was the only element of TEW operations in SEA that presented a doctrinal dilemma as to where it was really formalized. The other elements presented no such problem.

TEW Operations in SEA

To this point, definitions and operations were treated. TEW operations in SEA included many of these, excluded others, and added still others. PECM actions included electronic reconnaissance, WILD WEASEL forces, SAM/AAA and MIG warning, some functions of the RIVET TOP aircraft, and ARDF. AECM activity included varied uses of jamming and deception. COLLEGE EYE aircraft were considered primarily in the early warning - command/control category.*

* TEW aspects of COMINT/ELINT activities will be published as an SI Supplemental Report, obtainable through AFSSO. It will follow the outline of this report and carry the identical title. When practical, each paragraph in the supplemental report will refer to the paragraph in this report which it supplements.

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Thus, security limitations and conceptional definitions established a general framework for a report on TEW activity. This framework was further modified by factors and requirements peculiar to the war in SEA. These factors suggested a final framework for TEW operations in SEA which is schematized in Figure 1. As might be expected, all activities responded to the acute demands of the war. No threat was more acute than the steady improvement and effectiveness, in a remarkably short period of time of NVN air defenses.

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TACTICAL ELECTRONIC WARFARE IN SEA
ELECTRONIC COUNTERMEASURES

ACTIVE

PASSIVE

Support Jamming - EB-66B/C/E

Electronic Recon - EB-66C

Chaff

Escort of C-130 - EB-66C

Navy EKA-3B/TACOS

TINY TIM (B-52 escort) - EB-66C

USMAC EA-6A, EF-10B

ARDF - EC-47, P-2V

Self-Protection Jamming - ALQ 71 Pod

HUNTER-KILLER - WILD WEASEL Forces

QRC-160-8 Pod

SAM/AAA and MIG Warning - RHAW Gear

ALQ-51

Prototype - RIVET TOP ECM Functions

ALQ-100

QRC 335 Pod

Communications Jamming - COMBAT MARTIN

(F-105F) (USAF has not
employed it)

EB-66E

EKA-3B

EA-6A

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CHAPTER II
THE EARLY YEARS
(January 1962-June 1965)

NVN Air Defense Posture

In 1964, NVN had an air defense capability which, for the time, was as rudimentary as that of the North Koreans in 1950. (Appendix II.) North Korean defenses improved to the point that considerable effort had to be expended to counter them and accomplish the mission. This was also true in SEA. When U.S. bombing efforts over the north first began in August 1964, NVN defenses consisted of approximately 1,426 guns, 22 early warning radars, and 4 fire control radars.^{1/} There were no jet aircraft and no SAMs. (By way of immediate contrast, an estimate of NVN capability in November 1968 revealed about 8,050 AAA guns, 31 MIG-21s, and 15 MIG 15/17s in NVN-- with another 106 MIGs in China, 35 to 40 active SAM battalions, and more than 400 radars of all types.)^{2/}

This early defense network did not severely impede U.S. bombing efforts. Alpha Strike Force aircraft flew at medium altitudes, above the lethal range of AW and AAA guns. Targets were relatively easy to acquire, and aircraft ran into defensive firepower on only that part of their bomb run below 5,000 feet. But this condition was not to endure; the days of a relatively threat-free environment over NVN were numbered. ROLLING THUNDER, the systematic attack on NVN, began on 2 March 1965; four months later, on 24 July 1965, an F-4C was downed by a SAM. From that day on, the effectiveness of the ROLLING THUNDER campaign depended upon U.S. ability to cope with an air defense capability of ever-increasing magnitude and sophistication.^{3/}

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By mid-1968, the NVN defense network employed electronic equipment of "varying power/beam width/function/polarization/numbers/geographical distribution." Because it combined this resource with SAMs, AAA, and MIGs--plus integration of the entire system--it was recognized as one of the most complex electromagnetic defense threats ever to be combatted by USAF tactical forces. Effective enemy use of camouflage, mobility, and emission control compounded the problems, because good use was made of the equipment while minimizing the possibility of direct attack. The threat was eventually mitigated enough to permit the Alpha Strike Force to sustain the ROLLING THUNDER campaign at acceptable loss rates. The TEW posture of the U.S. in SEA, however, was initially somewhat bleak.^{4/}

Between the termination of the Korean conflict and commitment of U.S. forces in SEA, tactical electronic warfare problems did not receive the focus they warranted. Thought, attention, and funds were apparently concentrated on strategic ECM problems. As a result, tactical air forces "were almost totally unprepared in Electronic Warfare equipments for a conflict of this type."^{5/}

TEW Posture

The U.S. TEW posture in SEA from January 1962-June 1965 was negligible. This was a time of extremely limited activity--particularly from January 1962 through mid-1964. ARDF was in the experimental or test stage. The existence of the SA-2 Missile System was known in 1958; TAC's role

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was regarded largely in terms of quick reaction alert (nuclear delivery by a single penetrator), and its forces had not prepared to fight the kind of war over NVN that evolved during 1965.^{6/}

In a very real sense, the posture was no better than the situation required, and remained so until a new sense of urgency dictated otherwise. The urgency in the ARDF area came with a COMUSMACV decision to expand his requirements for coverage by a factor of nine. A similar sense of urgency developed when it became essential to provide the Alpha Strike Force with the means to survive over NVN. When the requirements were recognized and established, in both instances the role of the CofS clearly stemmed from his responsibility for service support to the EW operations of unified commanders, and his responsibility to the JCS for EW policy in the execution of ROLLING THUNDER.^{7/} As the year 1965 ended, TEW came of age. No modern military force, let alone tactical air forces in SEA, could survive without effective ECM.

AECM

The first U.S. airstrikes were launched against NVN on 5 August 1964. USAF operations over the north began with the Flaming Dart retaliatory strikes, one on 6 February, another on 10 February 1965. The tempo of bombing activity was further increased with the first unilateral USAF strike which launched ROLLING THUNDER in March 1965. Initially, U.S.

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aircraft enjoyed a very brief period of uncontested air superiority when bombing selected NVN targets, although tactical aircraft were "virtually without Electronic Warfare protection." Except for a small number of Navy attack aircraft, U.S. attack forces had neither self-protection nor were they ECM equipped. Before too long, a "desperately needed capability" was "patched together."^{8/} As NVN defenses improved, U.S. tactics had to adjust accordingly to survive and accomplish the mission. At times, this was painful and costly; from the summer of 1965 through early autumn 1966, "the situation facing strike pilots over North Vietnam was indeed grim."^{9/}

Some models of the QRC-160 pod were in the Pacific, but they were all located at Kadena AFB, Okinawa. Pods were first deployed in SEA in late March 1965. At Tan Son Nhut AB, Vietnam, they were put on RF-101s located there for reconnaissance. Support was a problem; however, a more serious deficiency surfaced. The pods were not constructed to endure in-flight vibrations and internal parts came loose. They also seemed to cause the RF-101 wing tips to tuck and some thought this could become a safety of flight item. The pods were shipped back to the U.S., and this experience cast a shadow of suspicion over them. It was believed that some ECM capability was necessary in SEA; accordingly, RB-66s (B and C) were deployed from Europe and the U.S. A new aircraft would have been preferable because of the age of B-66 airframes, but something had to be done quickly.

The earliest ECM capability exploited over NVN was that provided by the B-66, the first of which arrived in the theater in April 1965. By

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18 May, there was a total of eight C models. These proved effective in reducing enemy ability to direct AAA fire by radar. "ECM operators were consistently reporting a capability to break the FIRE CAN lock-ons...."

The focus of activity at this time was against terminal radars. NVN demonstrated a capability to construct, occupy, and operate an 85-mm radar-controlled gun position within six days. Weapons were concentrated in areas that were probably predictable; the Air Force commander's targets were limited, and he could not select the frequency of attack.^{10/}

Prior to April 1965, NVN possessed 31 early warning radars, 2 height finders and 9 AAA control radars, showing an increase over the August 1964 figures. By July 1965, and as a result of ROLLING THUNDER, the NVN radar inventory doubled to 76 sites.^{11/} A MIG threat appeared in April but seemed to fade. The most ominous development in April, however, was the revelation through photo reconnaissance of the construction of two SAM sites. Within the next few months, the magnitude of the construction effort was confirmed, and a FAN SONG, track-while-scan radar emission, was intercepted by an RB-66C (later EB-66C) on 23 July. The next day, speculation gave way to reality. Two missiles were fired into a flight of four F-4Cs; one aircraft was downed and the other three suffered major damage.^{12/} From then on, it was a different "ball game" in the employment of airpower over NVN, as tactics had to be revised to cope with this very real and dangerous threat to the Alpha Strike Force. The question of the survival of this force conducting ROLLING THUNDER operations precipitated a crisis

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reminiscent of the one in Korea in mid-1952. Survival also figured heavily in the ground fighting in SVN.

PECM

Turn the element of survival around, and one had an explanation for the interest shown in ARDF activity. Here, the survivability of friendly ground forces was the key. Through the ability to monitor, locate, and fix enemy troops, COMUSMACV hoped to substantially improve his planning and execution of the ground war against an elusive, mobile enemy.

As indicated in Chapter I, some remarkable things had been accomplished in the past through interception of an adversary's radio transmissions-- but hardly on a sustained basis, and certainly not to the extent that became routine in SEA. One of the most important PECM activities during the war was that of ARDF. As stated in CHECO Report, "The EC-47 in Southeast Asia", of 20 September 1968:^{13/}

"The EC-47 Tactical Electronic Warfare Squadrons are an important 'first' in Air Force History. This is the first time that the Air Force has ever organized, equipped, and, for the most part, trained personnel for such operations in a combat zone. There has been, and still is, no comparable activity in the Continental United States."

The roots of this development stretched back to 1961; they grew to the point where ARDF activity became an integral part of every major ground operation. This substantial growth was initially nourished by persistent efforts to develop equipment and techniques which could ascertain and exploit such vital information from an airborne platform.

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U.S. efforts stemmed from an historical Signal Corps involvement with ground radio direction finding. Experiments in SVN with airborne equipment--using the aural null technique--began in earnest in January 1961. Solving the ambiguity problem and plotting sufficient LOPs to fix the transmitter proved to be a relatively time consuming proposition. In 1962, from General Curtis E. LeMay, at that time Air Force Chief of Staff, the USAF worked to develop a system that reversed the instant, unambiguous bearings to a station that the OMNI system provided.^{14/} One early Army program sought to use light aircraft in conjunction with a P-2V mother ship acting as a command/control vehicle. During the same year, a new ARDF system, installed in a C-54 and employing this same principle, was tested in SVN. "The lack of maneuverability of the C-54, problems with the new ARDF system, and difficulties with the U.S. Army agency supporting HILO^{15/} HATTIE (project code name) were key factors in the failure."

A joint USAF/USN project, MONA HI, continued the efforts until USAF assumed full responsibility in August 1962. The project was then called HAWK EYE; equipment was developed to enable angle measurements on a radio signal, without human judgment, in one second. When used in conjunction with a system enabling the aircraft to pinpoint its own location, ARDF showed great potential. Although SEA tests on the new system between February and July 1964 were unsuccessful, the HAWK EYE aircraft (C-47) was returned to SVN in October. It had received stateside modification, which, within a short time, proved its worth. Coincidentally, MACV

interest in greatly expanded ARDF coverage was communicated to PACAF.^{16/} These developments spurred ARDF employment to very significant proportions. Thus, improvements in the NVN air defense system, the launching of the first SAM, and successful tests of the first practical ARDF capability (demonstrated with HAWK EYE), set the stage for EW operations during the subsequent three years.

Tactical ECM Comes of Age

A significant turning point in the history of Electronic Warfare occurred in July 1965. "To a very limited base, the Soviets and Chinese supplied weapon sophistication...." USSR and Chinese technical and material support for this system began within a few months after the U.S. bombing of NVN. Within a year, 25 SAM missile battalions appeared, where there had been none; training and logistical support were also supplied.^{17/} Thus, despite the small size of NVN, the country presented air defenses which ranked among the most dense and sophisticated yet seen by U.S. tactical air forces. When confronted with a crisis, interest in ECM heightened remarkably. This was also true of a crisis in the ground war.

During the first half of 1965, U.S. troops were rapidly deployed to SVN to cope with a deteriorating political and military situation. It was a very critical period during the ground war. Interest in an efficient, workable ARDF capability was heightened by the need for rapid acquisition and exploitation of information on enemy movement and concentrations.

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An electronic "tug-of-war", much like that which took place during World War II and in Korea, was about to begin. After two previous relapses, U.S. TEW capability needed another injection. New techniques had to be developed, or old ones reapplied, to insure or improve the chances for friendly force survivability. Every effort was made to acquire an edge in a contest that EWOs in SEA sometimes compared to the old "Carnival Shell Game." For the next three years, many efforts were initiated to provide tactical forces with the odds that favored the manipulator in that game.

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CHAPTER III

ECM ROLE IN ROLLING THUNDER (Part II: July 1965 - December 1968)

In a message to 5AF/13AF, of 14 December 1968, CINCPACAF said: ^{1/}

"Prior to initiation of air operations over NVN, the Tactical Air Commands were practically devoid of EW equipments and personnel. Crash efforts to develop, procure, and employ EW capabilities to meet SEA requirements were both late and costly. This situation was fostered by lack of emphasis on EW equipment, manpower, and organization at command level. When command emphasis was brought to bear on acquisition of EW equipments, the effort was hampered by lack of proper EW officer manning and organization throughout the structure of the Tactical Air Forces."

This commentary, made in early 1965, indicated how the tactical ECM posture had deteriorated after the Korean War; this was the condition that had to be rectified--and quickly. For the next three years, the TEW story was characterized by frustration and concern; by applied resourcefulness in a race against time; by accelerated effort to overcome years of inertia; and finally by the achievement of a measure of success in a battle of technology and wits. Success was essential for the continuous employment of airpower over NVN.

TEW Support for ROLLING THUNDER

Between 1965 and 1968, EW units were engrossed in three general tasks: (1) ECM support of strike aircraft and development of tactics to

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exploit ECM denial of effective enemy use of his electronic equipment;
(2) timely warning of MIG/SAM activity, and (3) performance of PECM. ^{2/}

Three general categories of ECM employment emerged; these were broadly considered as support ECM, self-protection ECM, and related ECM such as HUNTER-KILLER forces and SAM/gun-laying radar suppression and warning. Several watersheds punctuated the application of EW resources and tactics against NVN. Each provided an opportunity for a retrospective comparison of debits and credits in the see-saw struggle--and influenced innovations.

One obvious watershed occurred in the spring of 1965 with the construction of SAM sites in NVN. Introduction of this weapon into the picture could have potentially denied the medium altitudes to the Alpha Strike Force, or eventually, it could have inflicted unacceptable losses on the force unless a successful counter was found. Thus, the time frame from the launching of the first airstrikes against NVN, until the first F-4C loss to a SAM on 24 July 1965, might be considered Phase I. Phase II then began and was marked by continuous, concentrated efforts to degrade NVN terminal defenses. From July 1965 to March 1967, the job of coping with the SAM/AAA threat held the highest priority. However, throughout Phase II, several developments presaged the approach of another watershed.

As indicated in CHECO Report, "Air Tactics Against NVN Air/Ground Defenses" of 27 February 1967: ^{3/}

"Radar, AAA's and SAM's began to display a

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high degree of discipline. The three systems were fully integrated under an excellent command and control net which, of necessity, extended to the fighter force also. This was a methodical, high caliber, tight control, multi-directional defense development, and it is significant to note that what took seven years to set up in the Soviet Satellite bloc, took but seven months (from April 1965 when the first SAM sites were photographed) in North Vietnam".

This was the general nature of the integrated NVN defense posture in early 1966. Also, SAM sites became more numerous, and SAM rings began to overlap and affected the orbit patterns and effectiveness of the EB-66 support jamming. Finally, two other factors contributed to a second watershed: (1) a realization that further NVN radar network sophistication enabled terminal threat radars to receive information from other sources and to postpone transmission until the last minute; and (2) the introduction of self-protection pods for U.S. aircraft. All of these elements combined to bring an end to Phase II, with Phase III beginning in March 1967. At this point, TEW efforts were directed toward the entire NVN electronic defense system, rather than at a part of it.^{4/} Phase III lasted until President Lyndon B. Johnson declared a bombing halt over all of NVN, commencing on 1 November 1968.

During Phase III, however, there was no standing still. Major changes in operations did occur; nevertheless, these were basically advancements and refinements of ECM efforts against the entire defense system. "The

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threat in NVN is now well understood and tactics have been designed to cope with it within the limits of theater ECM resources...The possibility of equipment modification or the introduction of new equipment into NVN is always present so the threat must be continually monitored." Only one word adequately described the TEW scenario in SEA--dynamic. Nothing dramatized this more poignantly than the loss of an F-4C to a SAM missile. With this portentous event, Phase II began.

Phase II--Jul 65-Mar 67

The SAM threat over NVN triggered a flurry of activity at PACAF because of the meager in-theater ECM assets. Platforms for intelligence and jamming were essential. One proposal was to use the RB-47H, but this was denied because of possible implications in employing a strategic bomber. Thus, the nod was given to the EB-66.^{5/} Initially, the EB-66Cs were located at Takhli, Thailand, while the EB-66Bs were at Tan Son Nhut, Vietnam. As of 16 September 1965, no B-66s were located in SVN; however, five B models^{6/} (Brown Cradles) arrived at Takhli late in the fall.

Prior to the SAM threat, the EB-66 support against the AAA radars was thought to be effective. Introduction of the missile into the NVN defense system necessitated changes in U.S. tactics. The EB-66s of the 41st Tactical Reconnaissance Squadron (TRS) (later changed to TEWS) then had the important task of warning the strike force of missile radar activity and

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jamming terminal radars (SAM/AAA) in the 2,700 to 3,200 MegaHertz (MHz) band. Early results suggested that they were effective; while uncontrolled or inaccurate SAM behavior could not be entirely attributed to ECM support, this contribution was considered significant. Yet, the EB-66, had one severe limitation; it could not survive by itself against MIGs or against the SAM/AAA threat.^{7/} In addition to support jamming, several other responses to the SAM threat were implemented.

The most immediate response occurred three days after the F-4C loss. A retaliatory strike was launched against the presumed launch location of the missiles (fired on 24 July) by a total of 54 F-105s fraggged for five targets: two missile sites, the Phu Nhieu barracks (believed to house missile crews), the Cam Doi barracks area, and a special armed reconnaissance over the SAM complex. Six aircraft were lost (none to SAMs), and only one pilot was rescued. Results were not very significant. Post-strike photo-analysis revealed that one site appeared to be an imitation designed to serve as a possible decoy and flak trap. While the second site appeared unoccupied, no damage was confirmed.^{8/} Early attacks against SAM sites were generally unsuccessful. One new approach was tried when a Navy A-4E HUNTER-KILLER accompanied an Air Force strike, on 31 October 1965, against two sites north of Hanoi. (The chief problem was to pinpoint a site accurately enough so that fighters could find and attack it.) Unfortunately, the Navy plane was downed, but not before its equipment helped solve the acquisition problem. Before being lost the A-4E guided the USAF

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planes into the area and marked the target. The Navy had few of these aircraft and needed the remainder to support its own forces. This led USAF to accelerate development of the F-100F, with improved equipment comparable to that in the A-4E. Between July and December 1965, a total of 222 USAF sorties were flown to seek out and destroy SAM sites. ^{9/}

Since very few SAM sites were confirmed as destroyed during this period and the number of them grew apace, U.S. strike aircraft were forced out of the medium and high altitude envelope. They evaded SAM guidance radar by approaching the initial point (IP) at lower altitudes, then popped up to medium altitudes when they sighted the target and rolled in on the bomb run. This tactic provided some protection against SAMs but not against AAA and AW. Aircraft losses to AA guns throughout the entire war exceeded by a substantial margin those lost to all other causes. ^{10/} Some means had to be found to combat the SAM threat and to restore freedom of action at medium altitudes, out of the deadly AAA/AW envelope. This was the basic reason behind the evolution of the IRON HAND/WILD WEASEL missions. In Korea, the mid-1952 crisis was triggered by the threat of searchlight control radars against night bombing operations. In SEA, the July 1965 crisis was triggered by the SAM threat. In both instances, the immediate reaction was predictable and logical--seek out the threat and destroy it. But HUNTER-KILLER operations proved to be no more of a panacea in SEA than they did in Korea, as problems had to be worked out.

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The concept was tried in SEA in early August 1965 and was called IRON HAND. Originally, F-105s were placed on ground alert to respond to any source which located a site, but within a week these aircraft were fraggd for armed reconnaissance over NVN. "IRON HAND alone had not proved practicable"; SAM sites were difficult to pinpoint, and even if they were generally located, they were moved before an IRON HAND flight could attack.^{11/} Another element entered the picture when the first WILD WEASEL aircraft (F-100F) arrived in SEA in November 1965. The arrival represented the culmination of one of the first projects of any kind in response to the first SAM launch the previous July. The WILD WEASEL I came equipped with the APR-25/26 and IR-133 (later ER-133) RHAW gear, which when employed, enabled the aircraft to detect when a radar threat came up on the air, and to home in on the source to mark it for visual acquisition and destruction by three other F-105s in the flight. The WILD WEASEL could also tell when the SAM missile guidance signal came on the air so evasive action could be initiated; an amber light warned that there was activity in the 700-850 mcs. spectrum, and a red light indicated that a launch was imminent. Subsequently, the term WILD WEASEL became associated with this type aircraft, although it more correctly identified the HUNTER-KILLER mission performed against SAM sites, independently of a strike force.^{12/} (This was to distinguish it from a new twist to the IRON HAND mission, suppression of radar defenses while an integral part of Alpha Strike Force ingress and egress.)

Anyone who has ever talked to WILD WEASEL crew members, or read of

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their exploits, knows that the mission could not have been more aptly named. However, arrival of the WILD WEASEL did not signal instantaneous success. The best, most feasible tactics, had to be developed; the element of surprise had to be used to advantage (primarily through skillful terrain masking); ordnance innovations had to be perfected; and further equipment modifications had to be accomplished.^{13/} However, despite these problems, the concept was initially successful, partially because revetted sites were easy to recognize when the Weasel gear brought the flight close enough to spot them. But the North Vietnamese quickly displayed a considerable amount of resourcefulness. SAM sites were not revetted, and camouflage and mobility were used to the utmost. AAA defenses protected SAM sites and firing problem (tracking) information was relayed from other sources. The Weasels found it more and more difficult to locate sites, and their attrition rate rose. These factors ultimately led to a different future emphasis for WILD WEASELS.^{14/}

At this point, it might be helpful to sum up briefly the several reactions to the SAM threat of July 1965. EB-66s were deployed from Europe and the U.S., and they provided an old but classic jamming platform. Retaliatory strikes were aimed at the suspected and known site areas. Reliable means were lacking to accurately determine range to pinpoint site locations and mark them for destruction. The Weasels helped, but they did not constitute a complete answer. Finally, strike aircraft adopted the pop-up maneuver when hitting a SAM-defended area. All these efforts were

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devised to counter a part of the NVN network, the most immediate threat-terminal defenses. There was really no other choice, given the ECM resources available to counter them and other deficiencies in ECM posture.

The time period of the gradual implementation of ECM measures and development of TEW tactics during Phase II against terminal defenses, when viewed in a total context, was known as the "pre-pod" period.

Evolution of TEW Operations

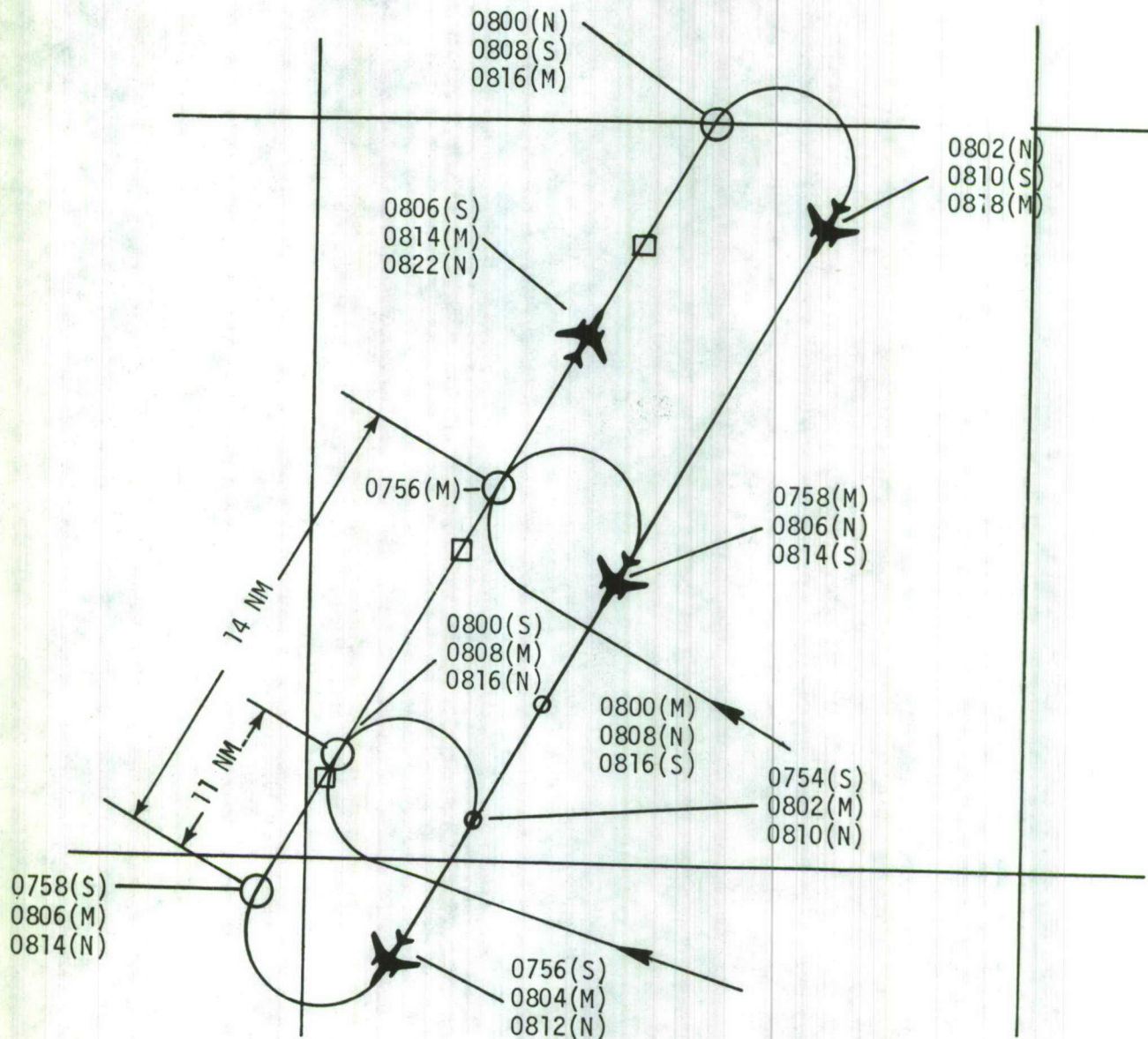
From April 1965 to September 1966, the B-66s provided the major electronic support in the theater to strike forces conducting raids over NVN. Initially, the mission of the EB-66s was to warn of SAM activity and jam SAM/AAA defenses. The EB-66B had 23 jammers; the crew consisted of a pilot, navigator, and EWO. These support ECM aircraft applied noise jamming, pitting the power of the jammer against the radiated power of the radar. Support jamming effectiveness was proportional to the distance of the jammer from the radar. The radar target also had less gain discrimination capability when the strike aircraft were on the same axis with, and between the jamming source and enemy radar.^{15/} Here was the classic application of active jamming--active ECM.

The EB-66C reckoned with the "perishable nature of an ECM advantage" by monitoring the NVN air defense environment for new equipment, equipment modification, or changes in employment tactics. (It was an EB-66C which

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SUPER ORBIT - 3 AIRCRAFT
(FRAGGED IP TIME: 0800)



LEGEND

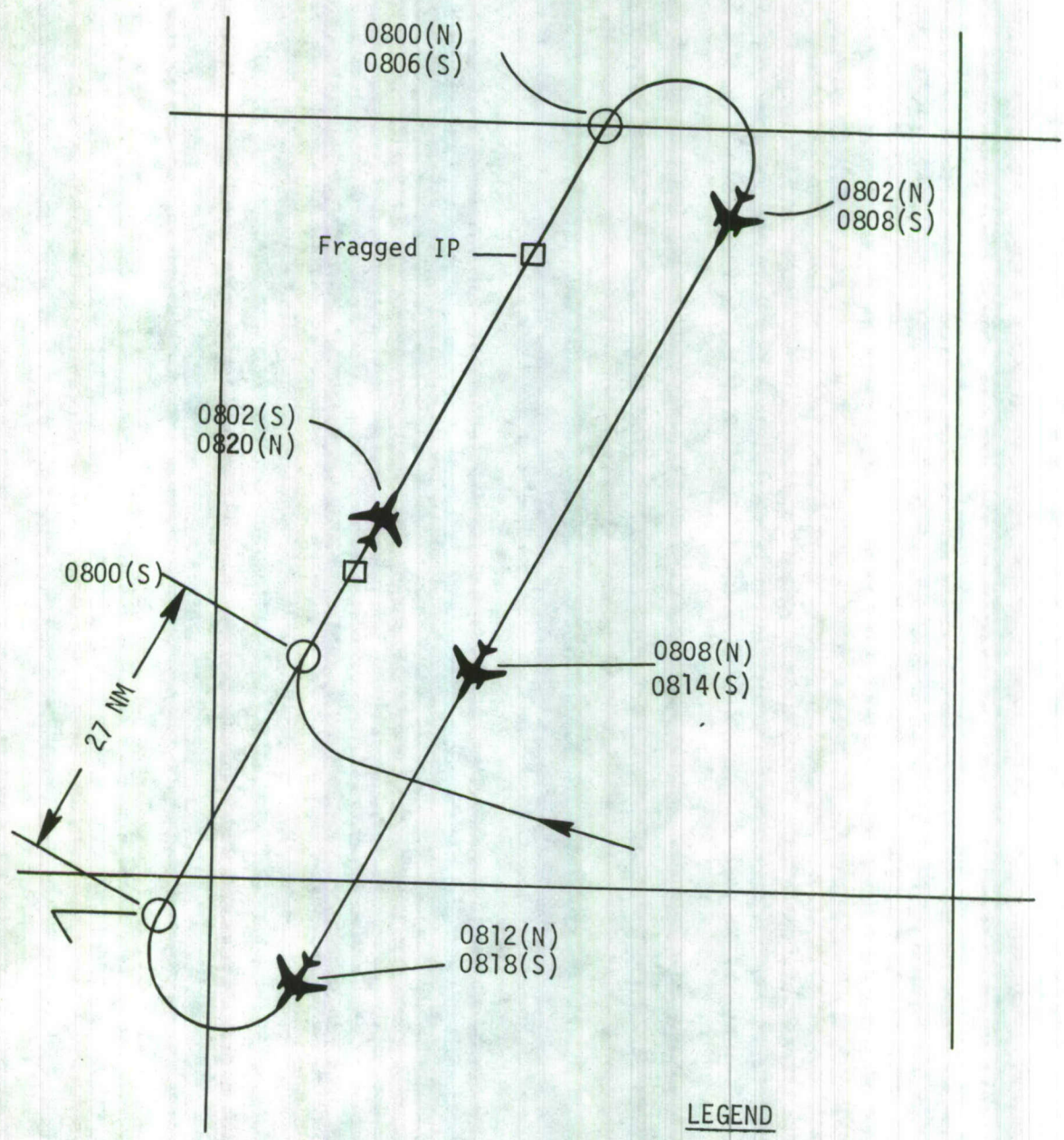
- N: Aircraft assigned Norther IP
- M: Aircraft assigned Middle IP
- S: Aircraft assigned Southern IP

FIGURE 2

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SUPER ORBIT - 2 AIRCRAFT
(FRAGGED IP TIME: 0800)



LEGEND

- N: Aircraft Assigned Northern IP
- S: Aircraft Assigned Southern IP

FIGURE 3

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EB-66 TINY TIM PROCEDURES

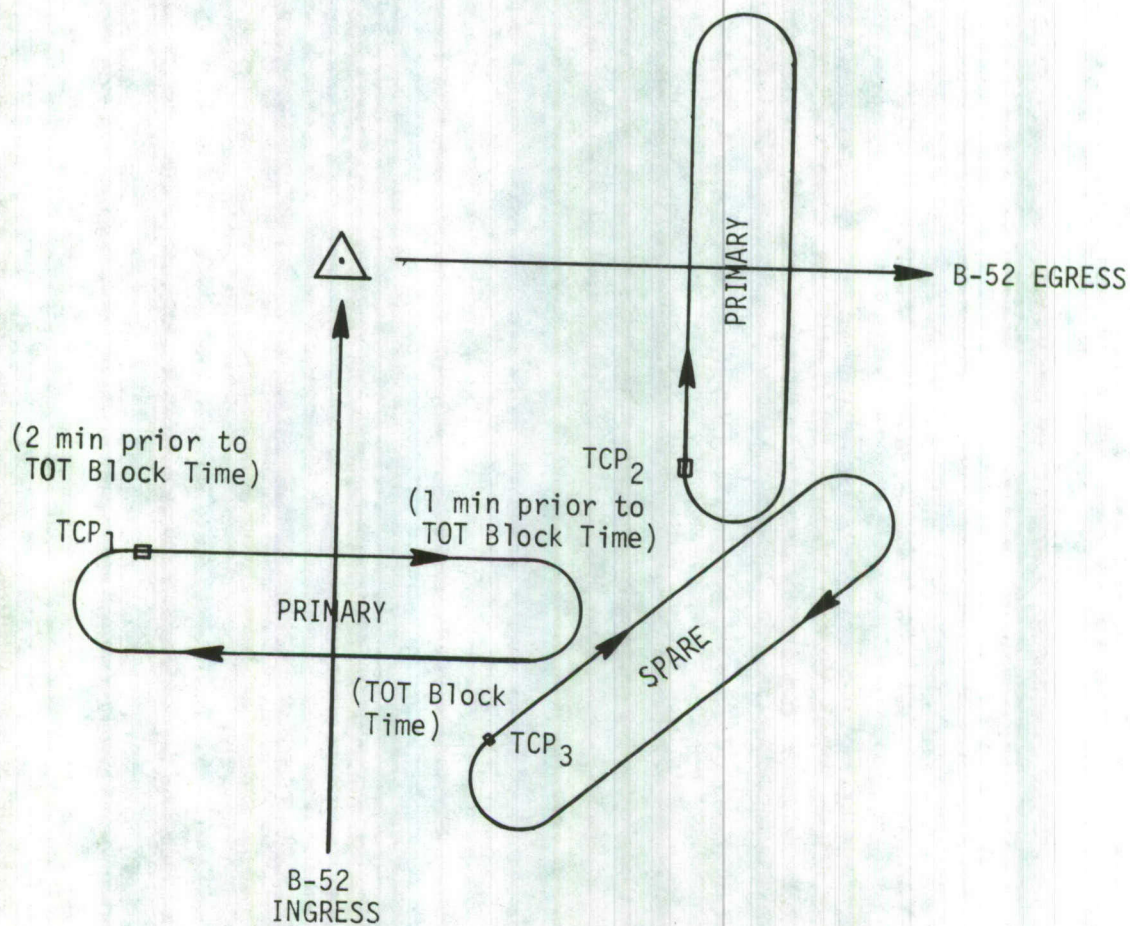


FIGURE 4

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picked up the first FAN SONG emission on 23 July 1965.) In carrying out the classic PECM role, these aircraft maintained a continuous surveillance of electronic emissions for information that could influence the tactical situation or update the enemy electronic order of battle (EOB). The PECM system aboard the aircraft contained receivers, DF equipment, recording instruments, pulse analyzers, and some jamming capability, mainly for self-protection. A pilot, navigator, and four EWOs comprised the crew. While the EB-66C flew electronic reconnaissance missions night and day, the number of these was small when compared to the total. Used for jamming initially, its eventual primary mission was to identify fire control signals and warn the strike force.^{16/}

Both models had a probe-and-drogue air-to-air refueling capability which extended its normal three-hour flight duration. Its optimum operating altitudes ranged between 25 and 30 thousand feet.

Over the years, ROLLING THUNDER operations presented an orchestrated scenario. Invariably, a patented sequence of events unfolded twice a day as strike forces and support aircraft proceeded according to plan to execute a bombing mission over NVN. B-66s entered early into the pattern of any strike; they required refueling and were usually the first aircraft to use the tankers before proceeding to their orbits. (Figs. 2, 3, and 4.) They were the major ECM echelon and provided jamming support for USAF, the Marine Corps, and the Navy. Before the SAM rings grew, B-66s operated close to target areas--where they could be more effective. In 1965 and

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early 1966, for example, northwest NVN became a choice orbiting area. Looking down "Thud ridge" right into the Hanoi target complex, EB-66s provided good support against AAA and SAM threats. However, by mid-1966 ^{17/} this picture changed.

Many factors made the ECM task a difficult one. NVN acquired about 20 different radars of all types, and the whole system could not be degraded. A single aircraft deployed against a single radar ceased to be effective. Using a combination of jamming, chaff, and crossing tracks, several EB-66s were then employed against it. Simultaneous jamming by two ECM aircraft reduced FAN SONG effectiveness but did not degrade it completely. But the most important factor affecting ECM support proved to be the rapid integration of the NVN defense network in conjunction with an increase in the numbers of SAM sites and in their performance. ELINT collectors of the USAF and USN provided ample evidence of the scope and magnitude of the development. The improvements manifested themselves in several ways. Toward the end of 1965, MIG/SAM integration was recognized. Additional time was also gained by NVN during the 24 December 1965-31 January 1966 bombing pause.

The NVN SAM order of battle on 15 February 1966 contained 134 sites-- 84 by analysis, 11 photographed installations, and 39 ELINT-gathered possibilities. ^{18/} On 25 February, an EB-66C was downed by a SAM. Accurate target information was being fed to the sites from other sources, and SAM techniques themselves were further refined. U.S. tactics had to be

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refined with them. When U.S. aircraft took proper high G evasive action, the SAM could be outwitted. When they did not, and were in the SAM effective altitude envelope, they were quite vulnerable. To take evasive action, aircraft had to be warned of an imminent or actual firing, or the pilot had to visually spot a SAM launch and prepare to out-duel it "face to face." While actual kills by SAMs were not excessive, the effectiveness of the SAM transcended this criterion, because the threat was real enough to trigger other side effects. Strike aircraft were forced to deviate from planned operations; frequently they were unable to approach the target as briefed; the medium altitudes were denied them; and they had to run the gamut of AW/AAA fire; finally, external stores had to be jettisoned before resorting to high G evasive action against an oncoming missile. All these factors had to be considered when measuring the SAM threat.

Location and destruction of sites retained a high priority. As previously mentioned, location proved to be especially difficult. One further improvement was tried with the introduction of the AGM-45 Shrike, radar-homing missile, the first of which was fired on 18 April 1966. Route Package I provided the early locale for developing operational tactics. While actual Shrike hits were virtually impossible to assess accurately, one favorable development was observed in FIRE CAN operations. Enemy active emission time was greatly reduced whenever a Weasel force, armed with Shrikes, was in the area; NVN radar operators were sometimes less effective.^{19/}

Performing this mission was one of the most hazardous jobs of the war, but it did serve to harass the enemy and to provide a vital supplement to

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other ECM efforts. The cost to WILD WEASEL I resources--both lost and damaged was high; replacements only seemed to fill the loss gap, rather than permit a reserve buildup. Work also continued on making the Shrike more effective. Tremendous interest was by now generated at all USAF levels to provide the resources necessary to operate over NVN--particularly within the political constraints which made the task even more difficult. Among the high priority actions being taken to enhance ECM capability was the development of an effective pod. Self-protection equipment had been absent heretofore, and it was a vital ingredient missing from the overall ECM picture.

Successful Introduction of Pods

Ever since the unsuccessful experiments with pods in SVN in 1965, work continued in the U.S. to iron out the problems. A 7AF OPlan Nr. 461-67, dated 16 September 1966, directed a combat evaluation of the QRC-160-1 pod. When 25 pods were deployed to the theater for this purpose, proper support was deemed essential, and procedures for their use were to be implemented. The pods took up ordnance stations and their employment called for revised thinking on formation flying over high threat areas.^{20/} They were radar-jammers preset to counter the emissions of the FIRE CAN and FAN SONG. The first tests began on 26 September and lasted several weeks. Missions were initially fraggged in Route Package I and gradually moved north toward Hanoi. On 8 October, a veritable "tour de force" mission was flown over the high threat Nguyen Khe POL area. The results were significant. Non-jamming aircraft were quite vulnerable in such an environment.

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As stated in CHECO Report, "Air Tactics Against NVN Air/Ground
Defenses, of 27 February 1967: ^{21/}

"High flying pod-equipped aircraft, spaced in good tactical formation, did not experience any 37-mm, 57-mm radar-controlled AAA or missile firings, although they purposely presented themselves as a straight and level non-evasive target at 85-mm and SA-2 point-blank altitude."

Self-protection ECM was born--and accepted; by November 1966 aircraft equipped with pods flew more safely over Hanoi. The tests demonstrated the pod was an "unequivocal success."

This success triggered additional benefits. Navigation and target acquisition improved. Optimum strike tactics were once again possible. Fuel consumption increased very slightly, because of the additional drag created by the pods; however, fuel was saved in the long run by eliminating any need to resort to evasive action at low altitudes. With the medium altitudes once again available for strike forces, less time had to be spent in the deadly AAA/AW envelope. Fewer aircraft were fragged for the sole job of flak-suppression, and more were available to strike targets. In short, success of the pod allowed numerous tactical changes and improvements to be made. High level priorities were assigned to the delivery of more (and improved) pod-jammers into SEA. The U.S. had now gone one step ahead in the dynamic ECM battle.

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Transition to Phase III

The successful tests of the pod could not have materialized at a more opportune time. NVN had rapidly built up its missile defenses to the point that interlocking SAM rings forced EB-66 support ECM aircraft farther away from targets. These aircraft could not survive without a MIG-CAP above 20° N and could not penetrate SAM rings. As EB-66 orbits retreated, their effectiveness against terminal defenses correspondingly decreased. Also, it was realized that as the year 1966 came to a close, terminal radars were getting enough tracking information from other sources to solve their firing problem, with only minimum transmission time needed to verify and fire. Now that ECM pods had proved themselves, a shift in jamming tactics was in the offing. Between January and March 1967, a different concept of EB-66 employment was devised. Since the pods provided fighters with self-protection against terminal defenses, EB-66 jamming was directed toward confusing the EW net and limiting the range of the NVN GCI system. A substantial portion of the enemy defense network came under attack, rather than just part of it; this represented an overall conceptual change of great significance. History attested the importance of combating an entire defensive system; USAF ECM operational doctrine made the same, distinct point. For the first time in SEA, resources were available to approach that goal. Several important consequences ensued, when an effective pod became a reality and was introduced into the inventory.^{22/} These manifested themselves in some important revisions in ECM missions and tactics--for EB-66s as well as other ECM efforts. While Phase III was noteworthy for a sustained attack on the NVN defense system, and this

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remained true until bombing over the north ceased, major changes in operations were implemented throughout 1967 and 1968.

As EB-66s worked against surveillance radars, orbit locations conformed to the rhythm of expanding or contracting SAM rings, or were altered for other reasons. In July 1967, SAMs were placed along Route 6 as far west as 104° longitude, and F-4s were withdrawn as MIG-CAP for use as bombers. Consequently, the orbits in western NVN were moved south of 20° latitude. The Navy supplied CAP for the Gulf of Tonkin orbits; so, these remained the same. Addition of more radio equipment and jamming improvements enabled movement of western orbits north once again to 21° latitude. On 15 and 20 November 1967, in response to the contraction of NVN defenses around Hanoi, EB-66s were fragged to orbits north of "Thud Ridge" and were protected by MIG-CAP. MIGs unsuccessfully attacked the aircraft on the 20th. After weighing effectiveness against risk, the EB-66 was not permitted north of Hanoi; it was considered too vulnerable--and too valuable to risk at that location. Before the year was out, pre-planned routes, specific jammer-on points, and "packages" were all introduced. The "packages" related to jamming configurations against EW/GCI radar only, and were designated to provide the best, most efficient distribution of jamming power to support a strike. Shortly after the beginning of 1968, and after an EB-66C was downed by a MIG-21, EB-66 crews were directed not to fly over NVN unless specifically fragged there. ^{23/}

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Subsequent to February 1968, the most important development occurred after the partial bombing halt over NVN on 1 April. ECM support was then concentrated on defenses in the panhandle of NVN, particularly in Route Package I and the Vinh area. Orbit locations, as usual, were related to and affected by political constraints and decisions.

In summary, EB-66 employment, orbits, tactics, and equipment were continually being studied, revised, and improved. During Phase III the EB-66 B/E role was defined as standoff jamming, the ECM support for combat operations within hostile territory, while remaining outside the enemy's defensive perimeter.

While standoff jamming attacked one part of the defense network, several categories of ECM were directed at other parts. Paramount among these was the QRC 160-1/ALQ 71 pod. Noise transmitters in the pod jammed the AAA/SAM control radars and protected a strike aircraft by denying range to the FIRE CAN/FAN SONG and by distorting elevation and azimuth indications in the FAN SONG. While this complicated the fire control problem, and forced the site to a less desirable mode of operation, single aircraft attrition still might have been high. The answer to this was the pod formation, the jamming effects of which were cumulative.^{24/} (Figs. 5, 6, and 7.)

The number of missiles fired per aircraft loss provided data for

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OPTIMUM POD FORMATION

(VARIATIONS USED IN PRACTICE)

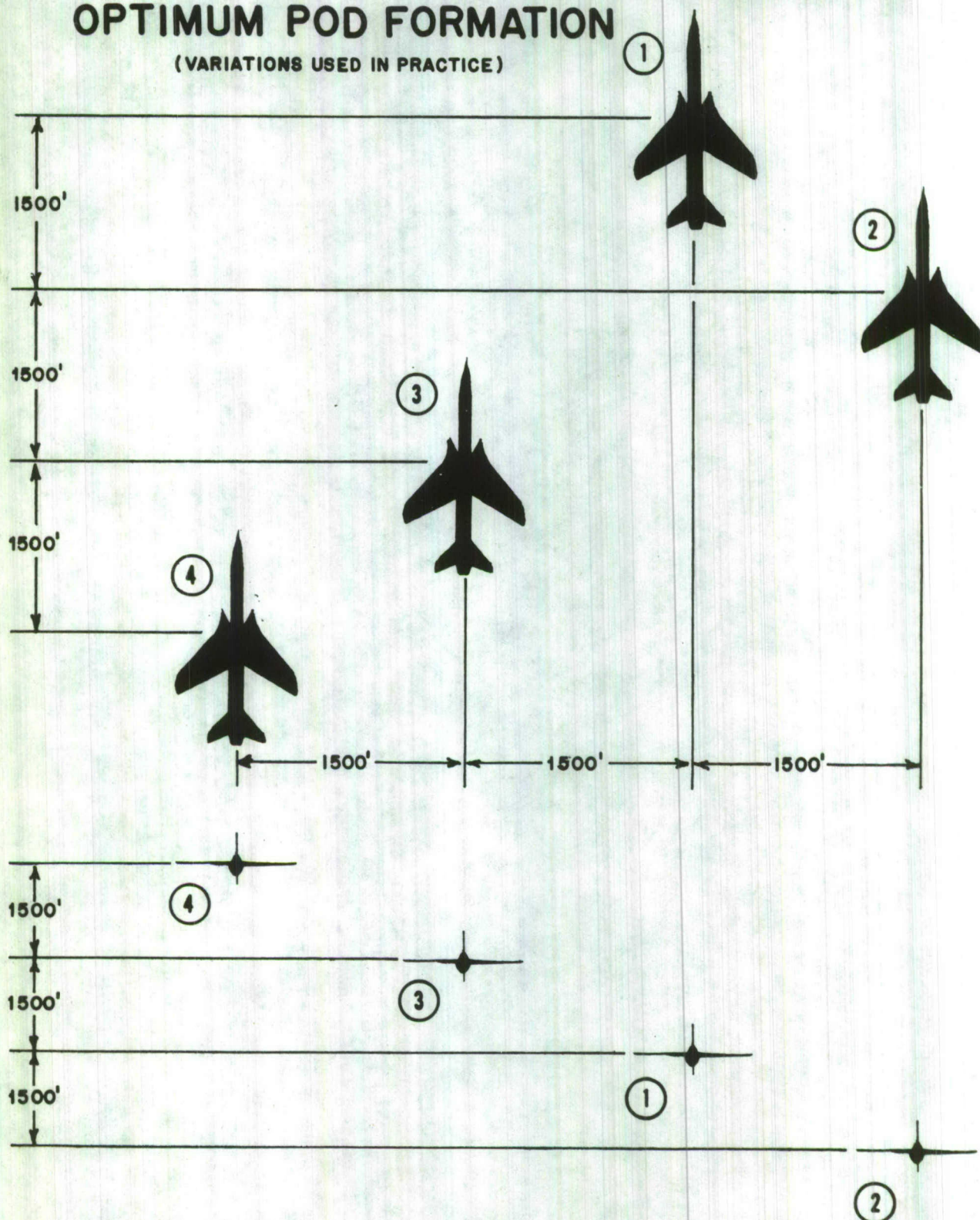


FIGURE 5

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355th TFW POD FORMATION

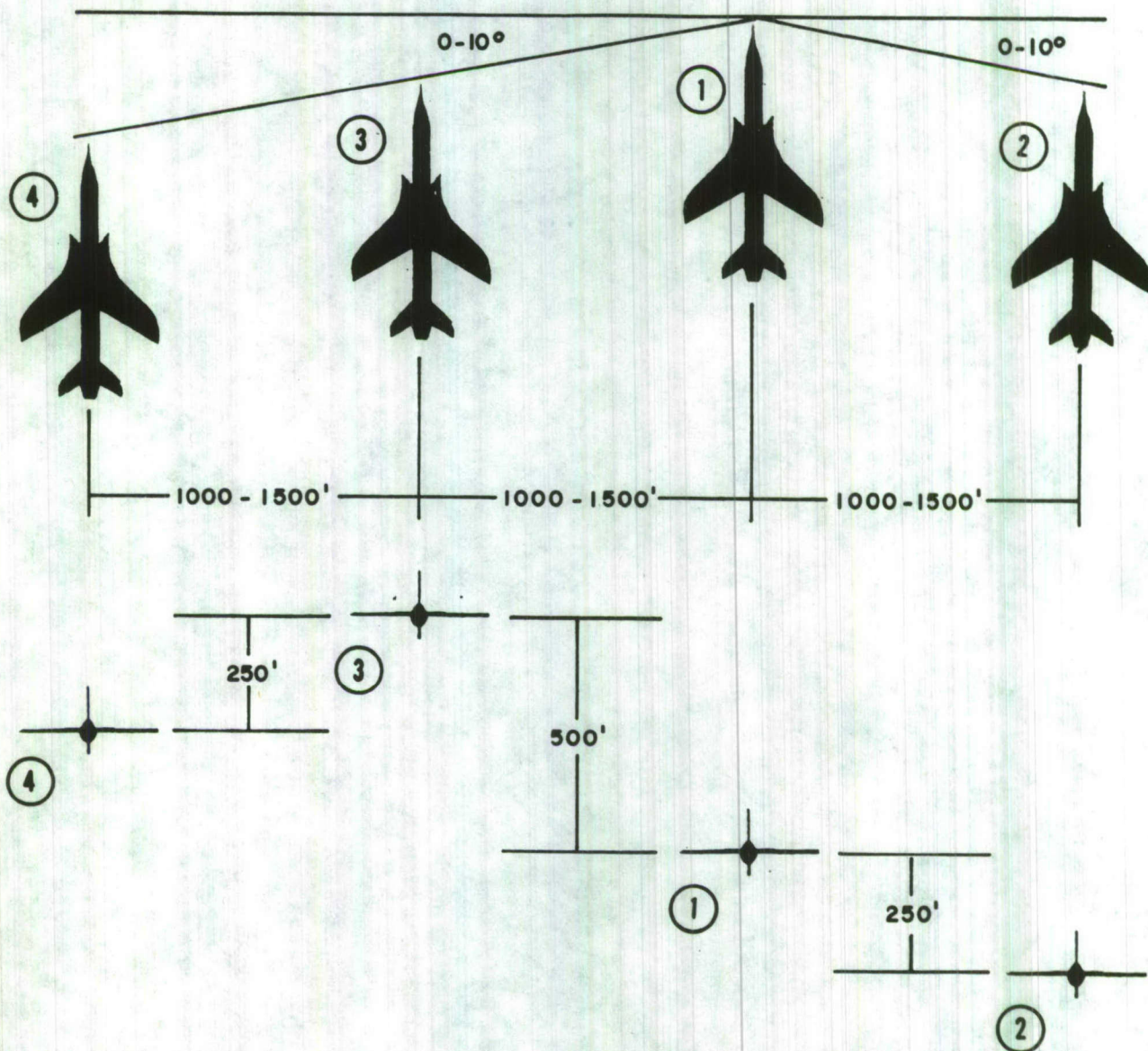


FIGURE 6

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388th TFW POD FORMATION

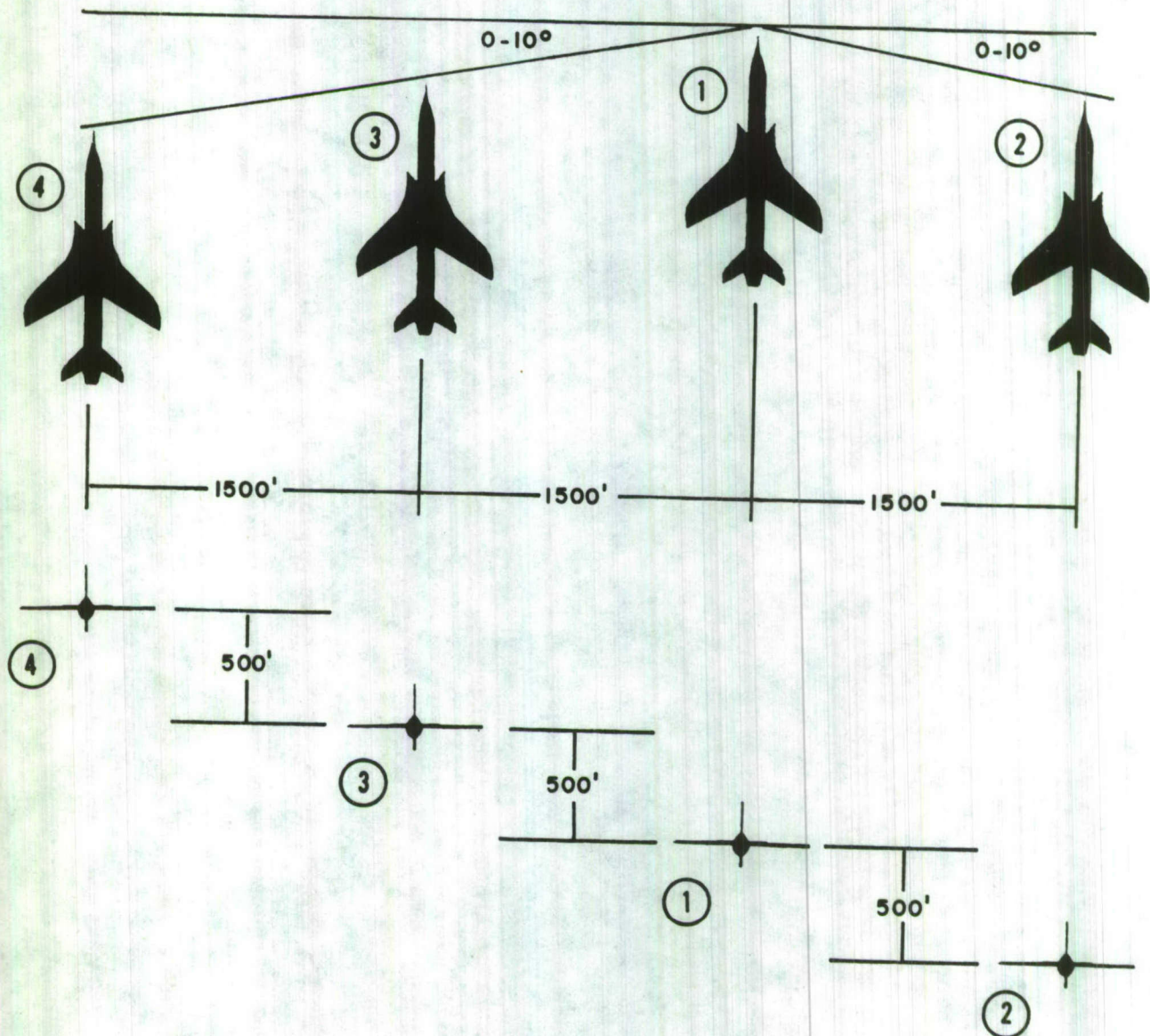


FIGURE 7

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analyzing pod effectiveness. In 1965, the figure was 12 to 1. A favorable turn occurred during 1966 as the ratio rose 30 to 1. From April through October 1967, approximately 83 missiles were fired per aircraft loss. During November, the ratio took an unfavorable turn: approximately 26 to 1. This was due to: (1) increased firing rate at two aircraft formations; (2) concentrated SAM attacks by several sites on the more vulnerable COMMANDO CLUB formations committed to straight and level, final bomb runs; (3) some MIG attacks which caused a break-up of the pod formation. Fortunately, analysis indicated the missile beacon receiver in the FAN SONG could be jammed; so pods were set accordingly. From 14 December 1967 to 31 March 1968, 495 SAMs were fired, with only three U.S. losses (165 to 1), two of which were IRON HAND aircraft not employing beacon jamming.^{25/} (Figs. 8 and 9.) Improved self-protection was afforded with the introduction of the QRC 160-8 and QRC-335 pods into the SEA inventory. The former generated more radiating power, while the latter incorporated noise and deception jamming; provided better single aircraft protection; and operated with little or no interference to RHAW gear. Prior to the arrival of the QRC-335, deception jamming was provided by the ALQ 51. The last internal, protective device eventually carried by all strike aircraft was RHAW gear, a PECM system, which warned of SAM/AAA threats and MIG AI radar use in time to initiate evasive action.^{26/} As indicated by these figures, self-protection ECM was effective. The degree of success not only influenced the alteration of the EB-66 role to that of providing standoff jamming against EW/GCI radars, but the IRON HAND mission also was revised. In

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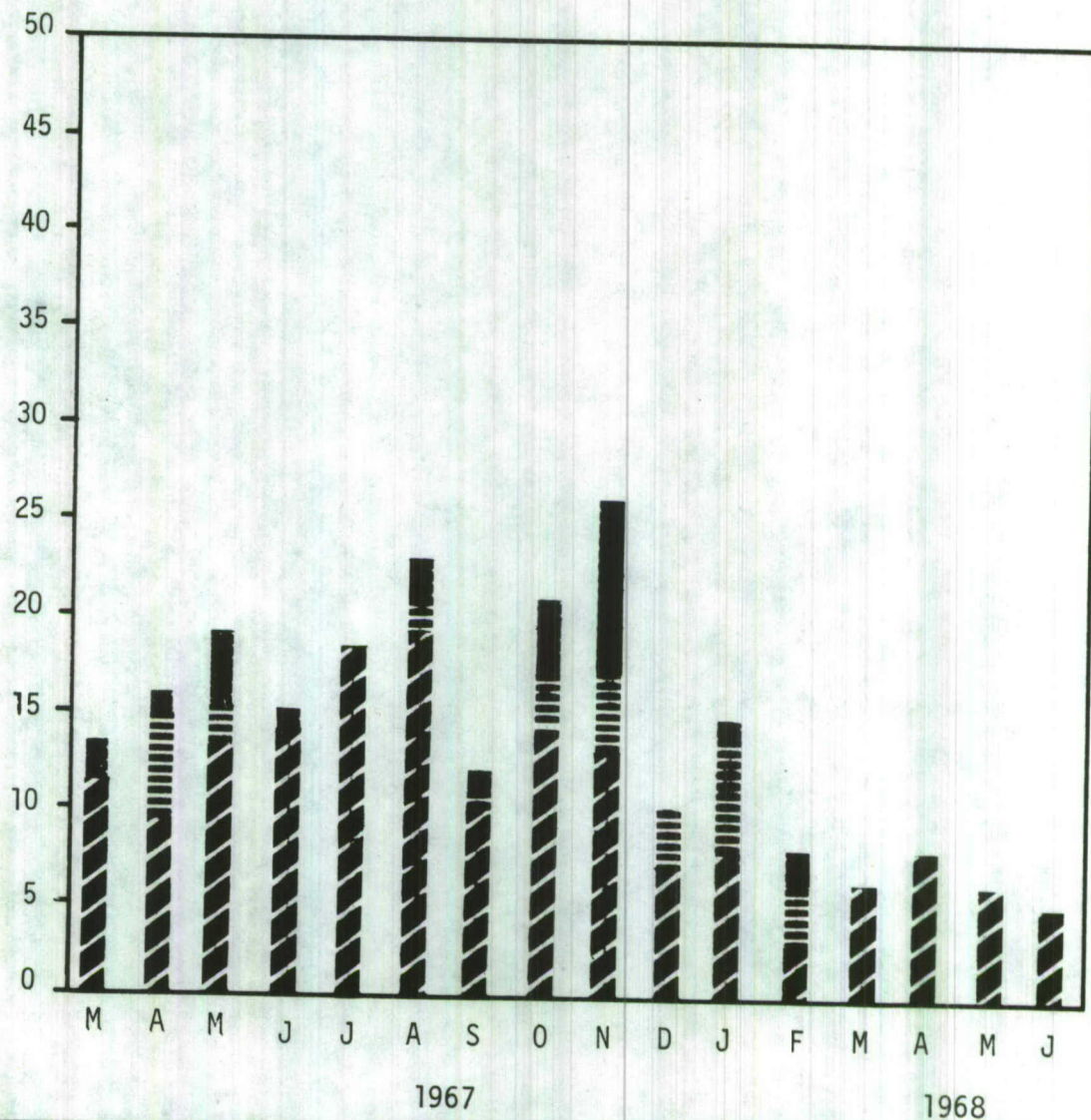
1965, the name defined the HUNTER-KILLER role. During Phase III, it became synonymous with the role of SAM/AAA suppression. Armed with AGM-45A Shrikes, and later the AGM-78 Standard Arms (and bombs), one IRON HAND flight of F-105s preceded the Strike Force into the target area by approximately one minute to monitor the SAM threat and suppress terminal defenses. Frequently, two flights accompanied the force. (Fig. 10.) When there were two IRON HAND flights, they positioned themselves in troll routes during the actual strike, thus dividing the area and providing full protection. IRON HAND flights were used primarily in the upper Route Packages prior to the limited bombing halt in April 1968. (The WILD WEASEL as HUNTER-KILLER, on the other hand, was employed primarily in the lower Route Packages--along the panhandle and DMZ. No USAF aircraft were lost to SAMs in Route Package I between 1 April and 1 November 1968. It was believed HUNTER-KILLER missions contributed to this success.) ECM pods degraded aircraft RHAW gear; so, IRON HAND flights were the chief source of SAM threat warnings while an integral part of the strike force. They also delivered Shrikes on strong signals, attacked sites as necessary, and generally protected the force until egress. ^{27/} When not required for flak-suppression, the F-105Fs were employed in the independent, HUNTER-KILLER or WILD WEASEL mission, largely in lower threat areas. However, during Phase III the accent on utilization of the Weasel aircraft had definitely shifted to flak-suppression for the strike force.

Actual destruction of a site continued to be difficult to achieve,

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TOTAL USAF AIRCRAFT LOSSES BY MONTH
(NORTH VIETNAM)



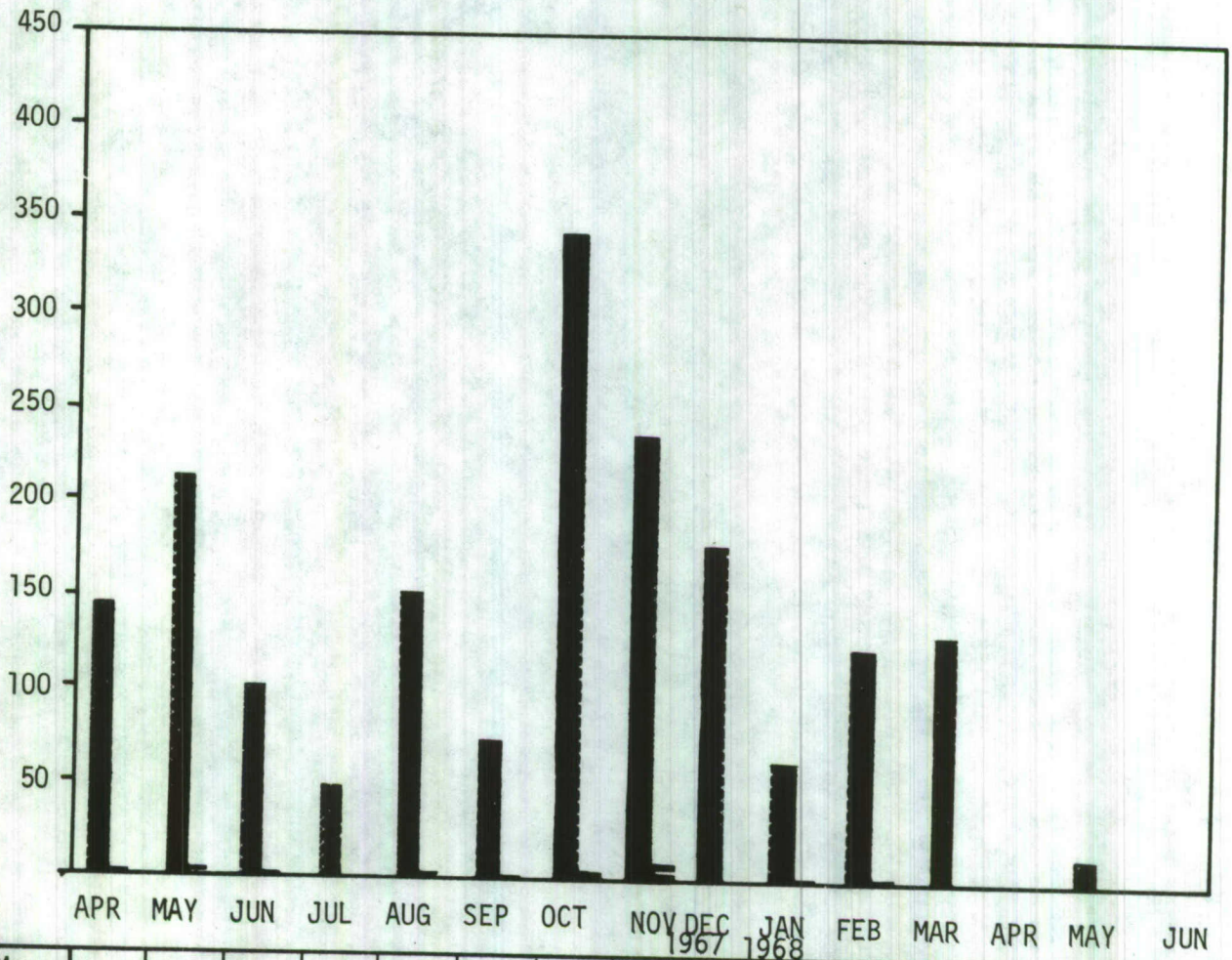
	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
TOTAL ACFT LOST	13	16	19	15	18	23	12	21	26	10	15	8	6	8	6	5
LOSSES TO SAMs	2	1	4	1	0	2	1	4	9	0	1	2	0	0	0	0
LOSSES TO MIGs	0	6	2	0	0	2	1	3	4	3	6	3	0	0	0	0
LOSSES TO GND FIRE AND UNK	11	9	13	14	18	19	10	14	13	7	8	3	6	8	6	5

FIGURE 8

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COMPARISON OF USAF AIRCRAFT LOST TO SAMs
WITH SAMs LAUNCHED AT USAF AIRCRAFT



	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
SAMs Fired	144	213	101	49	152	73	343	237	179	62	123	131	0	14	0
Acft Lost	1	4	1	0	2	1	4	9	0	1	2	0	0	0	0

FIGURE 9

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TYPICAL STRIKE

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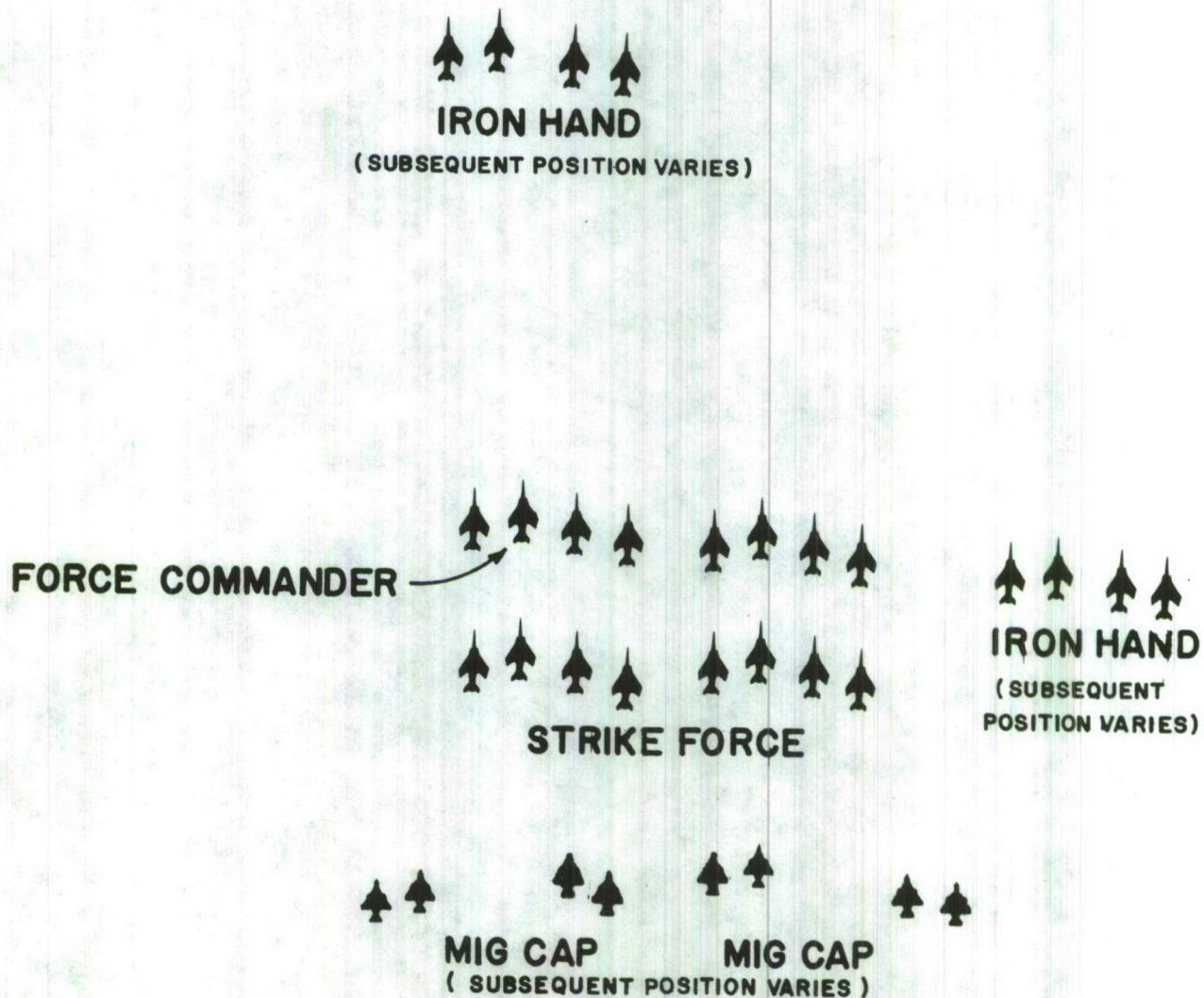


FIGURE 10

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as well as difficult to confirm. Even so, analysis of Shrike launches showed that when they had the opportunity, SAM sites launched a missile only 5 percent of the time if "Shrieked", but 45 percent if not.^{28/} (Fig. 11.)

To complete the picture of SEA capability, several other EW elements must be mentioned briefly. COLLEGE EYE and RIVET TOP provided additional capability for DF and MIG warning. COLLEGE EYE aircraft were equipped with a MIG warning device that was tied into the command/control network. RIVET TOP was a prototype EC-121M aircraft deployed to SEA for combat evaluation from 23 July to 15 December 1967. The initial TDY commitment (120 days) was extended in stages to 31 January 1969. RIVET TOP was equipped to perform several valuable functions: (1) locate active SAM sites and vector IRON HAND flights for the kill; (2) detect SAM site readiness, even in the "dummy load" (not actively transmitting but ready to do so immediately), and issue a warning; (3) locate active low frequency (30-300 MHz) EW radars; and (4) detect and locate MIGs and relay the information to friendly aircraft.^{29/} Even a quick glance at these functions suggested the extensive commitment of RIVET TOP capabilities to the support of ROLLING THUNDER. (The Navy had similar capabilities in its Big Look aircraft.) Beyond RIVET TOP and COLLEGE EYE two other USAF ECM assets completed the picture. Chaff was employed extensively by EB-66s and F-4s to further confuse NVN radars and add another element to the attack on the whole network. Communications jamming aircraft (COMBAT MARTIN) were in theater in 1968 but not employed to date; they were programmed to fly as either a strike or IRON HAND aircraft.

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Thus, from the first ROLLING THUNDER strikes in March 1965 to the complete bombing halt over NVN on 1 November 1968, an ECM drama in three acts unfolded on the SEA stage. As soon as the sustained nature of ROLLING THUNDER became apparent to the enemy, a race began for ascendancy in a contest over NVN. The enemy, with outside assistance, rapidly built up his radar capability and number of SAM sites, then integrated the whole system with MIGs and GCI. When the first U.S. aircraft was downed by a SAM missile, the conflict took an ominous turn for the U.S. By scraping the bottom of the ECM barrel, frantic efforts and considerable energy produced sufficient ECM assets to mount an attack on NVN terminal defenses. But there were some grim moments during 1966. Finally, the "Battle of the Beams" in SEA turned favorably for the U.S. In retrospect, the introduction and successful combat test of the self-protection pod came in the nick of time. It altered the course of events in the ECM drama. When strike aircraft in pod formation were capable of degrading terminal defenses, the EB-66 provided standoff jamming against EW/GCI radars. Then the major part of the NVN defense network was attacked with old resources being applied in new ways, with novel or revised tactics, and with continued injections of new equipment. The nature of the contest was dynamic, as ECM battles tend to be, and the U.S. enjoyed an edge from March 1967 to the November 1968 bombing halt. A high price was paid in lives and resources to achieve it; to lose it again through inertia would be folly.

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INFLUENCE OF SHRIKE ON SAM REACTION
(Oct 1967-Mar 1968)

Reactions (missile launch) were compared when Shrikes were launched/not launched and a potential target was within 15NM of an occupied site. The following chart shows results:

	<u>NOT SHRIKED</u> <u>OPPORTUNITIES</u>	<u>REACTED</u>	<u>SHRIKED</u> <u>OPPORTUNITIES</u>	<u>REACTED</u>
Oct	174	59	58	3
Nov (17 18 19 20)*	43	36	38	5
Nov (1-16 21-30)	60	21	30	0
Dec	80	42	34	0
Jan	49	30	69	1
Feb	90	37	35	2
Mar	64	25	45	5
TOTALS	560	250	309	16

* These four days are presented separate from the remainder of November, because of the unusually high number of SAM reactions noted. On these days, strikes involving unusually large number of aircraft, were conducted against well defended targets in the high SAM threat area which resulted in the launching of approximately 130 SAMs.

FIGURE 11

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CHAPTER IV

PECM AND RELATED TEW EFFORTS

While the application of ECM in support of ROLLING THUNDER occupied center stage, other TEW activities were going on in the wings. These were largely PECM efforts, with consequences frequently as significant in their impact on the conduct of the war in SEA as the direct support of ROLLING THUNDER. The EB-66C played an extremely important role in this regard. Daily evaluation of TEW activities by several agencies in SEA played a significant part in keeping the ECM odds tilted in favor of the U.S. Evaluations of current activities facilitated problem solving and fostered innovations. The ARDF program in SVN became one of the vital elements in ground operations. Of all ECM efforts, that contributed by the EB-66s was easily the most varied.

Other B-66 Support Roles

Versatility was the key ingredient in the work of the EB-66C. At any given time, although regarded as a PECM system, these aircraft were fraggged on electronic reconnaissance, AECM, or PECM missions. As noted in Chapter III, reconnaissance constituted a smaller proportion of C model missions. Yet, the information gathered was voluminous and frequently vital. In November and December 1967, 420 signals were collected on enemy radars, and 44 percent of them had CEPs accurate enough for EOB purposes.^{1/} Between 5 June and 16 July 1968, the 355th TFW (DCO/66) submitted 891 signals, and 60.8 percent were used to update the Master Electronic Order of Battle (MEOB). Of 242 signals intercepted and reported from active missions, 79.3 percent were used to update the MEOB

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and 46 intercepts were placed in the suspense file for future EOB applications.^{2/} Whenever a new signal was identified, another aircraft was immediately fragged into the area for confirmation. These are just a few examples of the enormous value of electronic reconnaissance. Feed-back of this nature continually influenced tactical operations.

The primary function of the EB-66C in support of ROLLING THUNDER was to provide threat warnings and jamming support, with the accent varying according to needs. It engaged in an AECM role only as a substitute for a B/E aircraft--and with approval of higher headquarters. When substituting for a B/E model fragged alone, or when in orbit with one, the EB-66C jammed terminal threats during the TOT block unless the other orbit aircraft left a major hole in the EW/GCI package. When no terminal threats emerged, it jammed any EW/GCI signals. Such activity was coordinated with the B/E aircraft to insure complete coverage of the enemy radar environment.^{3/}

First priority for EB-66 employment in SEA went to TINY TIM support of B-52 missions. SAC provided DOCRE at 7AF with TOTs and indicated how many EB-66s and IRON HAND flights were required. The composition of EB-66 support depended upon target location and known threats. One spare was added to the request. The support aircraft arrived at their orbit IPs a minimum of 15 minutes prior to the first B-52 TOT, and remained on station until at least 15 minutes after the last TOT. When the B-52

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target was within 20-NM of a SAM site, three EB-66s were normally fraggd for support jamming. Orbits were flown perpendicular to bomber ingress and egress routes, with the spare across the hypotenuse. With a target more than 20-NM from a site, two aircraft (a primary and a spare) were fraggd to fly the same orbit.^{4/} Spares could fill in for a primary abort, provide additional jamming, or fly another mission removed from the target area.

Following TINY TIM, manned recon in the Route Packages, headquarters directed missions, and Alpha Day and Alpha Night requirements, in priority came two other missions which received ECM support. These were BUMPY ACTION (photo drone) activities and FRANTIC GOAT (leaflet drops). Requests for support of BUMPY ACTION came from OL-20 at Bien Hoa, and indicated the time periods ECM was desired. On FRANTIC GOAT, psychological warfare (psywar) leaflet drops, the EB-66 pilot rendezvoused with the C-130, weather permitting, and escorted it to the drop area in formation. He then circled above during the drops, rejoined, and escorted the returning C-130 until ECM was no longer required.^{5/} The last two priorities for added EB-66 support went to the Navy and ELINT, respectively.^{6/}

In retrospect, the EB-66 fleet in SEA was called upon to provide support for an incredible variety of missions. After July 1965, no aircraft flying over NVN could survive without ECM protection, and EB-66s were tasked to support all types of missions whose success depended on countering some electromagnetic threat. This aircraft was literally the

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ECM "workhorse" in SEA for three and one-half years. The B-66 was an old airframe and in performance it represented a previous era of jet aircraft. But the situation in SEA called for maximum use of the capability it offered against formidable electronic defenses, and in this regard the B-66 was indispensable.

The application TEW resources in tactical operations was only as good as the ability to analyze and improve tactics and employment concepts. In such a dynamic area as ECM, proper electronic warfare evaluation became indispensable to daily tactical success.

EW Evaluation and Assistance

Two important efforts of this kind eventually materialized in the theater, COMFY COAT and Anti-SAM Combat Assistance Team (ASCAT). COMFY COAT originated in October 1966, when headquarters USAF tasked USAFSS to "develop the capability for comprehensive evaluation of USAF EW effectiveness in SEA combat operations." The following areas of interest were identified: EW support, self-protection, WILD WEASEL, ARM operations, and RHAW. In March 1967, electrical and hardcopy reporting began. The first electrical Immediate Reaction Report (IRR) was issued on 9 March 1967; the first monthly hardcopy report ("Electronic Warfare Evaluation Summary - SEA") was distributed on 31 March 1967. The latter commonly referred to as the "MSR."^{7/}

COMFY COAT analyzed events--or a specific event--within certain time frames and geographical areas. Sources included U.S. equipment characteristics, mission data, and tactics--plus order of battle data and

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intelligence on NVN reactions. For any IRR oriented event selected to be analyzed, every element pertaining to the mission was exhaustively scrutinized and reconstructed for evaluation. For the MSR, activity for a 30-day period was examined in the same way. In addition, special reports were published on subjects of particular importance or interest.^{8/} USN and USMC air operations data became available in November 1967. A team of personnel (headed by an EWLO from USAFSS), which provided the COMFY COAT field extension in SEA, arrived in theater in July 1967. Operational control of the team was given to 7AF (DOE), and direct communication to AFSCC was authorized. By mid-1967, and EWLO was also assigned (or authorized) to the wings at Da Nang, Vietnam, and these air bases in Thailand: Takhli, Udorn, Ubon, and Korat. This completed the interface between tactical wings employing EW and the COMFY COAT evaluation program.^{9/}

ASCAT represented a parallel assistance program, with special attention and interest in equipment and its tactical use. The team idea originated at Eglin AFB, Fla., and its effort began with the first WILD WEASELS that deployed to SEA in 1965. ASCAT's chief function was to provide assistance to tactical units. The scope of ASCAT gradually increased subsequent to 1965; for example, it inherited the pod program. Eventually, every TRW and TFW which employed pods had an ASCAT with the exception of the 12th TFW and 460th TRW. Each team consisted of an EWLO and pilot (Operations Staff Officer); they were an integral part of the wing commander's staff. Seventh Air Force (DOE) exercised operational

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control over the teams and provided a feedback link to CONUS organizations. The teams were active in all anti-SAM areas, providing systems improvement reports, monitoring of RHAW gear, pod improvements, new methods for dispensing chaff, analysis of combat tactics, as well as others. ^{10/}

The two primary evaluation and assistance activities, COMFY COAT and ASCAT complemented each other. The combination eventually became established at the Wings and at 7AF; a close liaison was also maintained with USAF Security Service at Kelly AFB, Texas, and with the Tactical Air Warfare Center at Eglin, Fla. What emerged was an ASCAT/EWLO team effort--analyzing daily EW operations in detail, identifying mistakes, confirming successes, meeting periodically to discuss both, proposing improvements, and gaining insights for the future.

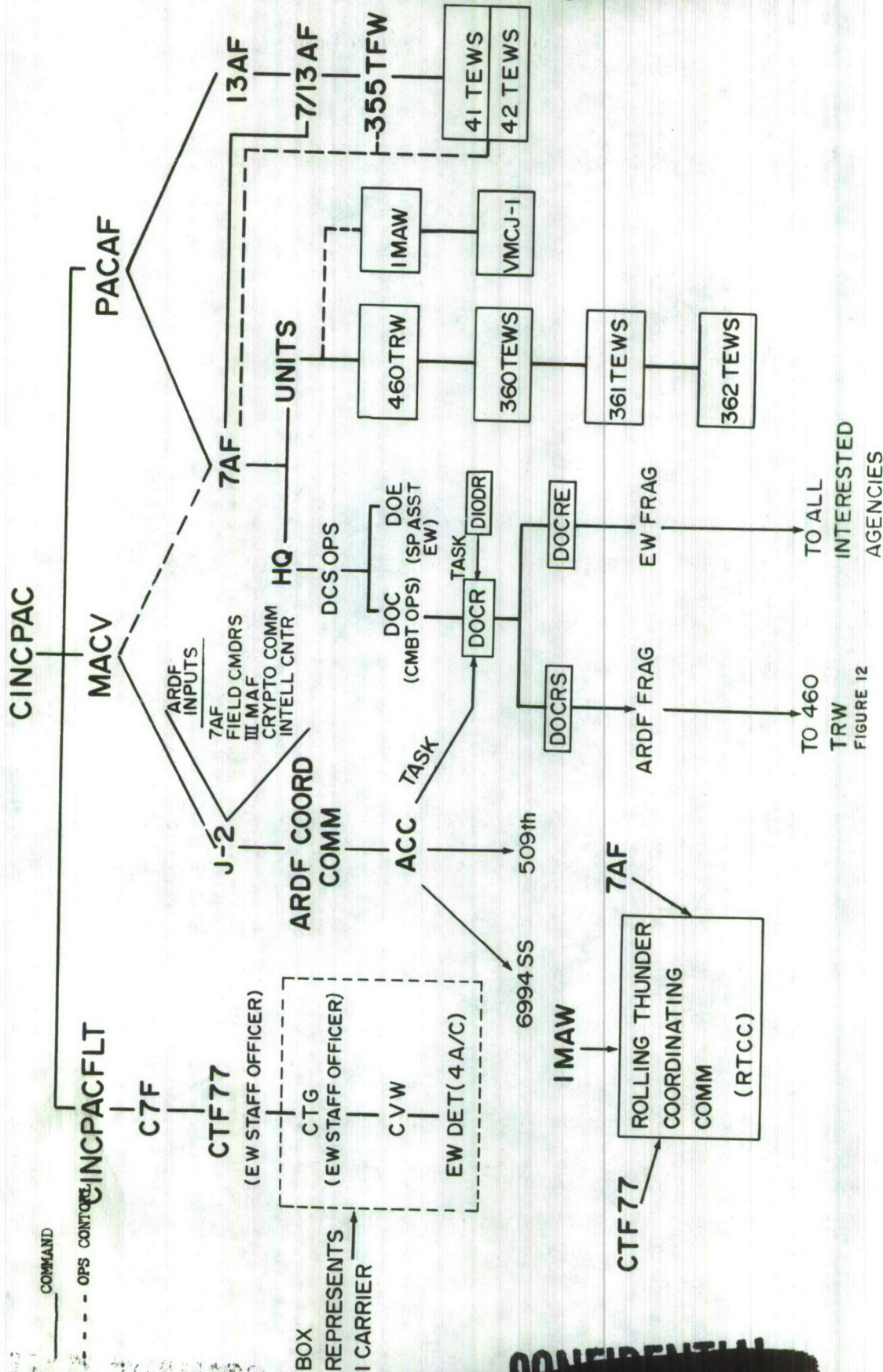
ROLLING THUNDER ECM efforts, other support ECM activities, and evaluation of EW operations--in fact, all USAF TEW operations in SEA were conjoined at 7AF Headquarters under DCS Operations. At this level, several organizations provided the central direction of the many and varied EW activities in SEA.

EW Organization in SEA

Two directorates under the DCS Operations (Fig. 12) shared responsibility for EW operations in the theater: Assistant for Electronic Warfare (DOE) and the Directorate of Combat Operations (DOC). DOE assisted

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with all EW operations in SEA. More specifically, assistance was provided in the following areas: (1) ECM systems and aircraft requirements; (2) tactical employment policy and doctrine; (3) planning and coordination of special SEA reconnaissance programs; and (4) evaluation and analysis of EW effectiveness. Three divisions and two attached units comprised the Directorate: (1) Applications Division; (2) Equipment Division; (3) Special Reconnaissance Division; (4) ASCAT; and (5) EWLO (COMFY COAT.)^{11/}

In the Directorate of Combat Operations, the daily management or fragging of EW operations was accomplished by the Reconnaissance/Electronic Warfare Division (DOCR). Within DOCR, tasks were divided among the following branches: in-country (DOCRI), out-country (DOCR0), electronic warfare (DOCRE), and special reconnaissance (DOCRS). The latter two branches were responsible for EW elements, DOCRE handling the daily fragging and coordination of all ECM efforts*--except ARDF missions which were the responsibility of DOCRS.^{12/} DOCRE was also the point of contact within 7AF Headquarters for Navy and USMC ECM activity.

DOCRE put together the daily ROLLING THUNDER EW frag order containing all ECM missions two days in advance. However, it developed the ability

* The Defense Analysis Division of DCS/Intelligence contained one branch, DIODR, which maintained a current SAM/ELINT/TEW OB. DOCR fragged aircraft to maintain this currency. Requirements to DOCRE indicated what the specific search requirements were.

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to react and make changes up to four hours before a mission. One portion of the frag order contained USAF levies; 80 percent of the possessed EB-66s were fragged. Any Navy support requests to 7AF were received by message, and these were balanced and measured against all priorities and the entire effort. After 1 November 1968, DOCRE also received information as to where the Navy positioned its own ECM aircraft, and these were included in the frag to inform the 7AF Command Center. The same procedures held true for ECM elements of the 1st Marine Air Wing (MAW) at Da Nang. CTF 77 also went directly to I MAW for ECM support.^{13/} Basically, DOCRE took USN and USMC frag inputs, ECM support requests, and USAF standard mission requirements--balanced these in terms of priorities and resources--and put together a daily frag for EW operations of all the services in the theater. The frag went out to all interested and participating agencies. The EW staff at the 355th TFW (Takhli) broke down the EB-66 portion of the frag and tasked elements of the 41st and 42d TEWS. In this manner the entire ECM effort was managed and coordinated. Once a mission was executed, deviations were rare; when necessary such deviations were handled by the 7AF Command Center through the appropriate Airborne Battlefield Command and Control Center.

When COMUSMACV designated the 7AF Commander as Single Manager for air in SEA on 7 March 1968, USMC aircraft, except helicopters and airlift, came under his operational control. One squadron (VMCJ-1) of I MAW comprised its EW contingent. This squadron, based at Da Nang, had eight EA-6A and six EF-10B aircraft. With initiation of the Single Manager concept, DOCRE representatives visited Da Nang to coordinate procedures. Since 13 March

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1968, at least five EA-6A/EF-10B aircraft were fragged daily to cover the DMZ for the 12-hour period of 0900Z-2100Z. Occasionally, additional PECM missions were fragged when requested by I MAW.^{14/} DOCRE was thus able to vary its own support in conjunction with the Marine frag. I MAW resources, beyond the five aircraft mentioned, were used in support of Marine strikes or to accommodate CTF 77 requests. While VM CJ-1 squadron ECM assets were operationally controlled, to a degree, by 7AF under the Single Manager concept, USN ECM capability had a unique organization tailored to the Carrier Air Wing.

USN EW Organization in SEA

Each Carrier Air Wing had four aircraft on board as an EW detachment. These aircraft provided the ECM support for strikes conducted by the wing. The Carrier Air Wing's operations officer fragged the missions for the EW aircraft, coordinating with the designated EW officer on the staff of the commander of the task group. Thus each carrier provided its own support jamming. However, the ECM efforts of all three carriers were sometimes combined, or the EW aircraft from one carrier were tapped to support the air wing of another. EW frags from each carrier were funneled to CTF 77 for analysis and approval by his EW staff. Tactical decisions on EW were made at task group level; technical decisions were made at task force level.^{15/} It was also at CTF 77 level that 7AF and I MAW interfaced to provide another point at which EW operations in SEA were conjoined. This was accomplished through the ROLLING THUNDER Coordinating Committee (RTCC).

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RTCC

Coordination of ROLLING THUNDER began as early as 28 November 1965 under the name, ROLLING THUNDER Armed Reconnaissance Coordinating Committee. Since that time, representatives of the USAF, USN, and USMC met quarterly (presently every four months) to discuss items of mutual interest. On each occasion, the decisions agreed to were written up in a signed, formal agreement. EW was one of the vital subjects taken up by a panel at the conferences. These included operations over the Gulf of Tonkin and improved fragging of the coordinated multi-service EW assets in SEA. Also by agreeing to give advance notice of their EKA-3B ECM aircraft, TF-77 permitted the 355th TFW and I MAW to take advantage of this added ECM effort in mission planning. Over the years, RTCC provided the opportunity for all the services to combine all their efforts in pursuit of one extremely important goal--the all out attack on the NVN electromagnetic threat to tactical air operations. Coordination, common purpose, and combination of resources were essential to this task.

Summary

While the magnitude of the ECM effort in support of ROLLING THUNDER was highlighted in Chapter III, this Chapter illuminated the variety, complexity, and scope of other EW activities. When considered together with those of ROLLING THUNDER, the effort was enormous. It had to be. U.S. ECM resources were challenged by an air defense system recognized for its relative sophistication and resourcefulness. The additional activities conducted by COLLEGE EYE, RIVET TOP, and other COMINT/ELINT programs affecting EW must also be considered in the total effort. Also very much

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a part of the overall TEW program was the significant in-country ARDF effort. These will be highlighted in a special supplementary report.

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CHAPTER V
CONCLUSIONS

When tactical air operations over NVN began sporadically in August 1964 and became continuous in March 1965, air war developments were reminiscent of the rerun of an old movie based on a Korean War script. U.S. tactical ECM resources were meager and not required, but NVN air defenses were also rudimentary. This situation soon changed. Considering the background of the country, and even with technological help, the buildup was remarkable and rapid. The complete air defense system was under centralized control, with one primary control center at Hanoi, one alternate at Phuc Yen, and a second alternate inside China. From any or all of these centers, a commander could control fighters, direct AAA barrages, and launch SAMs. NVN and ChiCom systems were integrated; the NVN-China border ceased to exist when it came to air defense. Well-trained crews operated the radar network and were aided by a proficient, radio-equipped spotter force.^{1/}

Conceptual Lessons

The record showed that tactical air forces were initially not equipped to survive in this kind of an environment. It could be degraded only by effective, continuous countermeasures, and U.S. resources in the theater were practically nonexistent. Accordingly, Phase II was synonymous with crisis, and Ad Hoc measures were implemented and crash efforts were made

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to acquire and provide the needed technological resources. Available assets, which could be gathered together, were first directed as a part of the defense network, until such time as a technological breakthrough was achieved with the effective pod and related tactics. Only then could a major part of the system be attacked and ROLLING THUNDER Operations be continued with acceptable loss rates.

There were some valuable lessons in the parallels between the Korean and SEA experiences with air defense and ECM. From some quarters came the criticism that in both instances, the U.S. was overly satisfied that at the outset of each war, its aircraft could not be denied access to target areas. The implication of complacency was strong, and while this kind of thinking prevailed, the enemy built and integrated a defense network which inevitably shattered any illusions about underestimating an adversary. Time compression became a progressively vital factor in the conduct of modern war, strategic or tactical. In Korea, the time span for the build-up was approximately 16 months; in NVN a much more effective defense network was completed in approximately seven months; in both instances a "wait and see" attitude was rudely confronted with a "what do we do now?" crisis. Quick solutions based on urgent Southeast Asia ECM requirements worked wonders under the circumstances; however, such a solution could not be considered a standard way to operate. A quick reaction capability was necessary to cope with the unexpected; it was not, and never would be, a substitute for an aggressive, effective, and up-to-date ECM program--with the latest equipment.

The template for building an effective air defense became quite well

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known since World War II. There was no mystery about it; the key ingredient was integration. With technical and technological assistance, this template could be superimposed on the most technologically backward country, and tactical air forces operating over it would then be placed in the identical Korean and SEA predicaments if not prepared. Inadequate ECM posture forced an interim attack on the most immediate, serious threat (normally terminal defenses) with makeshift, reactive efforts. Technological "know how" has been America's "strong suit," and the technological state of the ECM art could (and should) keep pace to provide the means for attacking an entire defense network. More succinctly, tactical air forces must have the means to preclude a "wait and see" attitude; they must prevent the template from being established. Barring that, the best, most advanced resources must be available to attack the whole system.

Since the NVN system was so effective, and since there were so many other related ECM requirements, all TEW assets were frequently combined and coordinated to buttress the overall ECM capability. Against an integrated defense one must pit an integrated offense. Any defensive radar environment can be degraded to some extent; it is only as good as its weakest link. In SEA, it took just such integration to establish a margin of superiority--the integration of a variety of elements. These included support jamming, self-protection pods, PECM, flak-suppression,

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HUNTER-KILLER operations, RHAW gear, revision of tactics, evaluation and assistance, COMINT/ELINT, and proper organization. And beyond this, the assets of USAF, USN, and USMC, when not used exclusively to support their individual efforts, were combined for integrated, mutual support. One example of the variety and cooperation will suffice to illustrate this last point. Between 1 April and 30 June 1968, the following EW support missions were flown:^{2/}

Alpha Strike Support (EB-66)	1,299
ARC LIGHT Strike Support (EB-66)	175
Navy Strike Support (EB-66)	9
PECM Missions (EB-66C)	258
Marine Strike Support (EA-6A/EF-10B)	626

Each individual element in the ECM picture contributed in some way to the eventual establishment of an EW margin of superiority. Meaningful summaries of the strengths and weaknesses of these various elements were available in the publications, "ECM Employment Concepts" and the final report of Project CREDIBLE COMET--a study of TEW.

Tactical Lessons

A support jamming platform was a vital necessity against the NVN radar environment, whether against terminal defenses during Phase II or against EW/GCI radar during Phase III. Numerous factors peculiar to the orchestrated nature of ROLLING THUNDER strikes and the geography of SEA served to alert NVN of a coming attack. The challenge was to integrate planning, equipment, and tactics in such a way as to generate as much confusion as possible,

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within generally the same time periods. From Alpha Strike Force ingress to TOT was approximately 7-10 minutes; degradation of the enemy's system for any portion of this time enhanced mission accomplishment and led to diminished loss rates.^{3/}

When conducting tactical air operations in a high threat area, the combination of support jamming, self-protection ECM, flak-suppression, and deception provided the only true formula for success. No one element, by itself, could have done the job. There were, however, several important considerations to the relative merits of standoff and penetration jamming. A rather large and diverse force was required to provide the support ECM for strike operations. The successful pod jammers and adoption of the pod formation were crucial factors in surmounting the Phase II crisis, but pods occupied stations normally used for ordnance.

While it was desirable to reduce the number of support forces, it was also difficult to envision how a support jamming platform could be replaced. TEW was so dynamic, so influenced by daily developments, that total flexibility was demanded. It would be difficult to conceive of any one aircraft in the near future, which could provide such flexibility against a totally integrated, radar defense system. The air war over NVN demonstrated the continuing need for a sophisticated jamming platform on a modern air-frame--one capable of the flexibility required to counter an equally

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sophisticated defense in depth. One solution suggested for restoring ordnance loads was to make self-protection ECM integral or modular with the airframe without reducing aircraft performance. TEW operations in SEA, regarding self-protection ECM, held one danger signal. The emphasis on pods and RHAW gear, which received too little attention initially, created a situation in which the amount of ECM equipment began to influence effective delivery of ordnance on the target.^{4/} All these efforts were essentially concerned with two principal aims: degradation of enemy radar and protection of the strike force.

One development in SEA turned out to be highly successful in providing protection for the strike force. This was the IRON HAND flight employed in a flak-suppression role. Theoretically, the HUNTER-KILLER concept had been attractive; in practice, the concept of destroying radar sites never fulfilled the aspirations of its advocates. In Korea, the concept failed; in SEA, on the other hand, it was much more successful. However, the real impact of the Weasels was made in the IRON HAND role as an integral part of the strike force. This concept, in conjunction with employment of the Shrike and Standard Arm missiles, was extremely effective in limiting SAM attacks and warning of SAM threats. IRON HAND flights had little ECM protection themselves, the anti-radiation missile needed improvement, and attacks were largely limited to SAM/AAA radars. Yet, these disadvantages pointed up the need to further develop a capability to locate and hit all types of radars. An ECM escort/penetrator might have saved the Alpha Strike Force from the agonies of Phase II in 1965-1966. When that experience

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was considered in conjunction with the excellent results achieved later in Phase III by IRON HAND flights in a suppression role, the validity and effectiveness of this concept had proved itself under fire. In SEA, the suppression role proved to be a vital element in protecting the strike force.

These same strike forces and their ECM support elements were no more effective than the continuous analysis of events and the assistance rendered operational units. Again, the dynamics of TEW required critical scrutiny of every aspect. COMFY COAT and ASCAT were giant strides in this direction. The close liaison which evolved between them provided the foundation for setting standards of effectiveness, both immediate and long-range.

In summary, to cope with the NVN defense network required a substantial, aggressive ECM program, careful and continuous electronic reconnaissance, and variance of routes and tactics. Standoff jamming, self-protection ECM, and penetration support were furnished to degrade the enemy system and protect the force. All these efforts were coordinated under some unique arrangements.

Command/Control Lessons

Command and control arrangements for TEW operations reflected the complexity inherent in many other aspects of the war. Since 7AF, MACV,

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CTF-77, and I MAW all conducted tactical electronic warfare operations, there was only one place where all efforts came together, and that was at CINCPAC. Each service operated independently, or under operational control of another agency, or in support of each other's requests--at any given time or all at the same time. In the theater itself, there were two points at which the efforts of all the services were either discussed or coordinated. At the planning level, this occurred when the RTCC met to discuss problems of mutual interest. At the daily working level, this occurred at 7AF Hq in DOCR. Both points of contact were very necessary because the threats and challenges presented to U.S. forces over NVN and Laos, in the extended battle area and in SVN proper, were of sufficient magnitude to require frequent cooperation and pooling of resources. There were also various roles and missions commitments and support requirements that had to be reconciled under USAF obligations to JCS, CINCPAC, and COMUSMACV.

Within 7AF Headquarters, one found perhaps the most concentrated, largest, and most unique organization for TEW in the entire Air Force. Nowhere else in the world were tactical forces actively engaged in such an electronic battle--one of tremendous scope and complexity. Under the DCS for Operations, a more or less prototype organization emerged during 1965-68. DOE and DOCR represented the culmination of efforts to provide the machinery for conducting effective TEW. These two agencies, with their varied and wide-ranging concerns and tasks, testified to the enormity and critical nature of the EW effort in SEA. This organization

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should be recognized for the unique creation that it represents, and should be thoroughly studied for possible duplication in other numbered Air Forces.

One example of a command/control anomaly, reflecting another of the myriad of complexities and peculiarities of war in SEA, was seen in the disposition of the TEW Squadrons. Three TEW Squadrons, committed to ARDF work in SVN and performing a PECM function, were assigned to a Tactical Reconnaissance Wing. They were tasked by a MACV agency which received request inputs from five other agencies--of which 7AF was only one. The bulk of the information collected was exploited in the conduct of the ground war. Two other TEW Squadrons, conducting AECM and PECM for ROLLING THUNDER over NVN and for various other SEA operations, were assigned to a Tactical Fighter Wing. This example illustrated the breadth of TEW activities--if nothing else.

Blend of Past, Present, Future

What worked in SEA will certainly not do the job everywhere--or forever. One safe prediction can be made about an ECM advantage; it was, and is, a fragile, fleeting thing that must be closely monitored and conscientiously retained. The advantage can be destroyed in an instant with enemy equipment modifications, new equipment, or revised tactics. A basically sound air defense system can be easily augmented and improved. For example, NVN's introduction of an operational C-band SAM system in 1967

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COUNTERING CURRENT AND POTENTIAL THREAT

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	JAMMING						DF WARNING				SUPPRESSION		
CURRENT THREAT	EB-66	SEAOR 167	POD & INTERNAL ECM	CHAFF	COMBAT MARTIN		EB-66	RIVET TOP	RHAW/WILD WEASEL	COLLEGE EYE		WILD WEASEL	WILD WEASEL BASE I & II
EW/ACQ	P	F	F	L			P	P	F			F	F
GCI/MIG	P	F	P	L	P		P	X	L	P		L	F
S-BAND AAA	L	F	X	L			P	P	P			P	F
S-BAND SAM	L	F	X	L			P	P	P			P	F
POTENTIAL THREAT													
X-BAND AAA	L		F	L			P		L			L	
C-BAND SAM	L		P	L			P	P	P			P	
X-BAND SAM	L		F	L			P		L			L	

LEGEND

F-Future Capability
 L-Limited Capability
 P-Partial Capability
 X-Little or no improvement
 against current threat

FIGURE 13

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could have turned the clock back for U.S. forces, because it would have created July 1965 all over again.^{5/} One way to prevent this from happening is to insure the possession and availability of a support ECM platform with the capability and flexibility to counter a changing threat, with sufficient jamming power to degrade EW/GCI radars and protect itself, and with the PECM system to survey the environment. Other categories of ECM must also be available to permit a total attack. Two wars since 1945 have made this lesson clear.

Husbanding an ECM resource could be a self-defeating course of action. ECM is too dynamic a field. U.S. resources were held back in Korea to no real purpose, because a capability that seemingly had to be protected was obsolete before long. No such luxury could be afforded in SEA, as various available resources were hurled into the breach.

As scarce as meaningful lessons sometimes are, the supply frequently exceeds the demand. EW came of age in SEA, but painfully. In the air war, a good deal of U.S. ECM capability was exposed, but the enemy exposed much of his also, thus enabling U.S. technology to counter it. This degree of U.S. exposure and compromise will be worth the price only if the right lessons are extrapolated. Soviet electronic capability will certainly be better understood--at least temporarily. True, mistakes were made, but a narrow EW superiority was eventually achieved. The cost in obsolescence of equipment and technology was small when compared to the more severe

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repercussions of losing the margin. With ECM technology there is no standing still; it either falls behind or forges ahead.

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FOOTNOTES*

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3. Ibid, pg 2;
(S) Report on USAF SAB, pg 10.
4. Ibid, pg 16;
(U) AFM 51-3, "EW Principles", May 63, pp 1-1,-1-6. (Hereafter cited: AFM 51-3.)
5. (S) Report on USAF SAB, pg 25.
6. (U) AHS, Nr 127, USAF Ops in the Korean Conflict, 1 Nov 1950-27 Jul 1953, 1 Jul 56, Vol VII, pp 41-43. (Hereafter cited: AHS Nr. 127.)
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8. Ibid, pp 69-74.
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10. Ibid, pg 78.
11. Ibid, pp 77-78; pp 248-251.
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13. (U) AF Dictionary, 1965;
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(S) AFR 55-90, 11 Mar 64.

* Extracted portions from TOP SECRET documents are classified no higher than SECRET.

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19. (S) AFM 2-8, 14 Jan 66, pg 1.
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21. Ibid., pg 5.
22. Ibid., pg 6.
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25. (U) AFM 2-6, Aerospace Operational Doctrine, "Tactical Air Operations, Tactical Air Reconnaissance", 1 Dec 65, pp 1-5, 7-8, 11, 16.
26. (SNF/ AFE0) "The EC-47 in SEA", pp 47-49.

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2. (S) 7AFP 55-2, ROLLING THUNDER Ops, 15 Jul 68, pg 12. (Hereafter cited: ROLLING THUNDER Operations.)
(SNF/ AFE0) Plan, 7AF, DPLP, Force Improvement Plan, Nov 68, pg A-9. (Hereafter cited: 7AF Force Improvement Plan.)
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4. (SNF) ECM Employment Concepts, 1 Aug 68, pg 2-1. (Hereafter cited: ECM Employment Concepts.)
5. (S) Report on USAF SAB, pg 4;
(S) Interview with Major Redman, 7 Dec 68.

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6. (S) Report on USAF SAB, pp 251, 445.
7. (S) "The EC-47 in SEA", pg 5;
(S) AFR 55-90.
8. (S) Report on USAF SAB, pg 4-5.
9. (TS) "Air Tactics Against NVN Air/Ground Defenses", pg 1.
10. (S) Interview with Major Redman, 7 Dec 68;
(TS) CHECO Rpt, 7AF, DOAC, "ROLLING THUNDER", 28 Mar 66, pg 60-61;
(S) Interview with Major Brees, 6 Jan 68.
11. (S) Manual, "Tactics Manual for SEA", 22 Feb 68" (Revised), Aug 68, pg 2-4. (Hereafter cited: Tactics Manual.)
12. (TS) "Air Tactics Against NVN Air/Ground Defenses", pp 8-9.
13. (SNF) "The EC-47 in SEA", pg vii.
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15. Ibid, pg 3.
(S) Interview with Major Redman.
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17. (S) Report on USAF SAB, pg 3.

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2. (TS) OpOrd, 7AF, Nr 100-68, ROLLING THUNDER, 15 Dec 67.
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10. (S) ROLLING THUNDER Operations, pg 12.
11. (TS) "Air Tactics Against NVN Air/Ground Defenses", pp 14, 18.
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(S) ECM Employment Concepts, pg 5-1;
(SNF/ 7AF Force Improvement Plan;
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(S) Report on USAF SAB, pp 155-156.
13. (TS) "Air Tactics Against NVN Air/Ground Defenses", pp 20, 21.
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16. Ibid;
(S) Major Render Report, pg 26.
17. (S) Report on USAF SAB, pp 132-135; pp 148-151.
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(S) Interview with Major Redman.
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(S) ECM Employment Concepts, pg 3-1.
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AFE0)

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3. (S) Information Book, EB-66C Recon and Jamming, 1 Sep 68.
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8. Ibid, pg 4.
9. (S) History Rpt, 7AF, Jul-Dec 67, pg 8;
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10. (S) History Rpt, 7AF, Jul-Dec 67, pg 8.
11. (S) History Rpt, 7AF, Jul-Dec 67, pp 5, 10-11, 16.
12. (S) Interviews with Lt Colonel Tarbox and Major Greene, 6 Jan 69.
13. (S) Interviews with Major Greene, Comdrs Boggs and Brown, 6 Jan 69.
14. (S) History Rpt, 7AF, Jan-30 Jun 68, pg 41;
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3. (S) ECM Employment Concepts, pg 3-4.
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APPENDIX I

DENSITY OF AAA COMPARISON OF AAA DEFENSES AT PLOESTI AND OVER NVN

The following information is derived from on-the-ground inspection of defenses of Ploesti supplemented by interrogation of anti-aircraft officers of the Rumanian Air Defense Command by study of captured defense plans and examination of action reports of various flak batteries. Although this information was derived from heavy bombardment attacks the tactical ideas in nearly all cases are applicable to medium and light bombardment plus fighters in some cases.

Flak defenses of Ploesti Refinery area (approximately five by six miles) were:

<u>Heavy Flak</u>	<u>Light Flak</u>
24 x 128 mm RR (10%)	64 x 37 mm Mobile (15%)
40 x 105 mm Mobile (15%)	366 x 20 mm Mobile (85%)
192 x 88 mm Mobile (75%)	
<u>256</u>	<u>430</u>

The above figures do not include 20 mm guns organic to each heavy battery or the obsolete and obsolescent 75 mm and 76.5 mm guns. COMMENT: Percentages tend to confirm reports that all German heavy flak consists of 65% 88 MM, 20% 105 MM, the remaining being 75 MM, 128 MM, 150 MM, etc., and the German light flak consists of 70% 20 MM, 20% 37 MM and remaining 10% being 50 MM, 40 MM, etc.

During one period the defenses of Ploesti fired an average of 46,000 rounds of heavy flak against each of four 14 group missions. Losses on these missions averaged thirteen heavy bombers, or an average of 3500 rounds fired per bomber lost. COMMENT: During six month period 1 October 1943 to 31 March 1944 the HAA defense of U.K. brought down an enemy aircraft for each 1620 rounds fired at seen targets and each 6790 rounds at unseen targets. Comparison indicates AA of U.K. compares favorably with Ploesti flak since visual firing was used by Germans in majority of instances. HAA in England was responsible for the complete or partial destruction of 62 enemy aircraft. Note visual firing was

SOURCE: AA Memo Nr 6, Hq Mediterranean Allied TAC AF, Intel Sect, subj: Flak at Ploesti, 4 Mar 45.

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over 4 times as accurate as unseen firing during this period in U.K.

It is interesting to note that when the optical flak instruments were not able to operate due to smoke and the radars were effectively jammed by our radar counter measures the Germans made use of "Thistle" aircraft for obtaining flak fire control data. The Germans had four reconditioned American airplanes (known as "Thistle" Aircraft) which would fly along with American aircraft and send radio reports on altitude, speed, and heading to the central control where it was converted into firing data. COMMENT: When M.A.T.A.F. B-25's raided Ostiglia on 10 November and the flak was extremely effective crews reported a single engine aircraft one mile to left of formation at same altitude in target area, which most probably was being used as a "Thistle" Aircraft.

The Rumanian officers who participated in the defense of Ploesti expressed the following opinions concerning maneuvers that aided flak defenses and their recommendations for future action:

A. The characteristics of attacks on Ploesti that aided the effectiveness of flak defenses were the stereotyped methods of attack for example:

1. Altitudes of attack were from 6000 to 8000 metres.
2. Attacks so close to schedule defenders never worried before 10 o'clock in the morning or after 3 o'clock in the afternoon.
3. After passing the I.P. a long straight bomb run to targets was made with no feints, evasive action or deviation.
4. After first attacks in April it became evident that one of about five well defended ground areas were being used for the I.P.
5. A standardized approach and departure system which, after two or three raids, was completely predictable because it was unvaried.
6. Speed was always within a few miles-per-hours of the average of first four attacks.
7. Attacks were made when weather conditions and clouds were favorable to our defense and optical range finding.

B. Recommendations for reducing the effectiveness of flak defenses were:

1. Diversify attack procedure reducing as many of the above aids to flak as possible. Avoid attack procedure that tends to become stereotyped.
2. Explore simultaneous use of smoke, incendiary and fragmentation bombs for flak neutralization and blanketing of optical fire control equipment.

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3. Amplify present use of radar jamming, chaff, and use both simultaneously with above.
4. Saturation of the defense by close spacing of successive formations in trail, so as to prevent engagement of each formation in a multiple formation mission.
5. Use of "dispersed" formations, when possible, rather than compact formations.
6. Restriction of straight and level flight to the amount necessary for bombsighting, with suitable evasive action before and after the bomb run.
7. Diverse target approach procedure, employing feints whenever possible.
8. Utilize, if possible, attacks through overcast clouds (radar bombing procedure will tend to mix up defenders).

COMMENT: It is realized that these factors are being taken into consideration, however, this information should prove valuable as a check list for planning flak evasive tactics.

From: "Report on Flak Defenses of Ploesti", Headquarters, A.A.F., Washington. D.C.

TAF/308/4/INT.

for Group Captain,
Chief Intelligence Officer,
Mediterranean Allied Tactical Air Force.

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APPENDIX II

1 Aug 68

THE ELECTROMAGNETIC THREAT IN NVN

1. The current electromagnetic threat in NVN is composed of radar equipment distributed throughout the radio frequency spectrum from 70MHZ to 3188MHZ. Because of varying power/beamwidth/function/polarization/numbers/geographical distribution, the threat is the most complex ever faced. Through the use of camouflage, mobility, and emission control the enemy has managed to make good use of his radar equipment while minimizing the possibility of direct attack. The burden of neutralizing enemy electronics is therefore carried almost exclusively by active and passive ECM.

2. For purposes of presentation the threat is broken into 3 categories by function. These are early warning/acquisition (EW/ACQ) radars, GCI radars and associated communications, and fire control (FC) radars associated with AAA or surface-to-air missiles. Radars used in NVN for GCA and meteorological purposes are not considered as a part of the threat. Although X-Band airborne intercept (AI) radars are carried aboard the MIG-17 and MIG-21 they are seldom if ever used since their use gives warning of attack to the radar homing and warning (RHAW) equipment carried by US aircraft.

3. The EW/ACQ radar threat covers the spectrum from 70 MHZ to 3125 MHZ. Included in this category are the Big Bar B which is capable of directing GCI's, although not ordinarily employed for this purpose, and the height finders, Rock Cake and Stone Cake. The radars are distributed geographically throughout NVN with coverage for a fighter aircraft at 15,000 ft as shown in Figure 5 Section III. The EW/ACQ radars deployed in NVN are as follows:

<u>NICKNAME</u>	<u>FREQUENCY</u>	<u>NUMBER</u>
Kniferest A	70-75 MHZ	6
Hi Dumbo	78-88 MHZ	16
Kniferest B	83-93 MHZ	40
Moon Face	102-111 MHZ	11
Spoonrest A	149-161 MHZ	34
Flatface	810-850 MHZ	40
	and 880-905 MHZ	
Crosslegs	1230-1280 MHZ	1
Rock Cake/Stone Cake	2585-2650 MHZ	10
Big Bar (6 Beams)	2700-2725 MHZ	3
	2720-2745 MHZ	
	2820-2855 MHZ	
	2970-2995 MHZ	
	2990-3020 MHZ	
	3080-3125 MHZ	

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<u>NICKNAME</u>	<u>FREQUENCY</u>	<u>NUMBER</u>
Cross Slot	2975-3055 MHZ	17

4. The GCI radar threat is comprised of the Barlock search radar and the Side Net heightfinder. These are the most capable GCI radars produced by the Soviet Union. The Barlock has 6 one megawatt beams stacked vertically and distributed in frequency in the S-band in approximately the same manner as the Big Bar above. The Side Net heightfinder operates in the frequency range 2550-2640 MHZ. There are 8 Barlock/Sidenet systems currently deployed in NVN as primary GCI systems. The primary GCI coverage for a fighter aircraft at 15,000 ft is shown in Figure 3 Section III. GCI communications are in the VHF frequency band. There may also be some capability for one way communications using the low frequency navigation receiver aboard the MIG aircraft in the band 100 KHZ to 2 MHZ. Other equipment used in GCI are the SRO-2 IFF and the Cross-up transponder. Frequencies of all equipment associated with GCI are:

<u>NICKNAME</u>	<u>FREQUENCY</u>	<u>NUMBER</u>
ARK-5 OR	150-1300 KHZ	
ARK-10 Radio Compass	120-1320 KHZ	
RSIU-3M OR	100-150 MHZ	
RSIU-5VHF Transceiver		
SRO-2	655-685 MHZ	
Cross-Up	723-746 MHZ	
Sidenet	2550-2640 MHZ	8
Barlock	2690-2720 MHZ	8
	2720-2750 MHZ	
	2810-2845 MHZ	
	2960-2990 MHZ	
	2990-3025 MHZ	
	3080-3120 MHZ	

5. The SAM fire control radar is the Fan Song B used with the SA-2 system. AAA fire control radars are the Fire Can and the Whiff. The Tachi I/Beam Track is a searchlight control radar to aid visual tracking by AAA systems. The frequency of bands associated with these systems and the numbers deployed in NVN are as follows:

<u>NICKNAME</u>	<u>FREQUENCY</u>	<u>NUMBER</u>
Tachi I/Beam Track	200-211 MHZ	UNK
Whiff	2656-2860 MHZ	3
Firecan	2696-2860 MHZ	75
Fansong	2880-3010 MHZ	34
	2980-3080 MHZ	
Missile Beacon	3100-3188 MHZ*	
Missile Control	704-797 MHZ	

* Tunable Range. Nominally at 3140 MHZ.

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<u>NICKNAME</u>	<u>FREQUENCY</u>	<u>NUMBER</u>
Unidentified Fire Control (Whiff or Firecan)		76

6. While the current threat in NVN is complex and diverse, there are several pieces of Soviet equipment not now deployed to NVN which would complicate the ECM picture even further. They are as follows:

a. Fan Song E operating in the range 4910 MHZ to 5090 MHZ. It has higher power, more directive antennas, greater missile range, better low angle coverage, and the LORO operating mode which will defeat some types of deception jamming.

b. Low Blow, the SA-3 control and guidance radar, operating in the range 9170 MHZ to 9420 MHZ.

c. Back Net EW/GCI radar operating in the range 1890 MHZ to 2460 MHZ.

d. Thin Skin heightfinder radar in the range 6460 MHZ to 6600 MHZ.

e. While X-Band AAA fire control radars have not been confirmed, there is a considerable body of evidence that such a piece of equipment has been developed. Russian technology has produced 4 AAA fire control radars which are operational aboard naval vessels and distributed in the frequency band 6500 MHZ to 9500 MHZ.

7. Of the radars representing the potential threat all except the Back Net and, possibly, the X-band AAA Fire Control radar have been deployed outside the Soviet Union.

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GLOSSARY

AAA/AW	Antiaircraft/Automatic Weapons
ABCCC	Airborne Battlefield Command and Control Center
AECM	Active Electronic Countermeasures
AFM	Air Force Manual
AFR	Air Force Regulation
ARDF	Airborne Radio Direction Finding
ASCAT	Anti-SAM Combat Assistance Team
CAP	Combat Air Patrol
CEP	Circular Error Probables
ChiCom	Chinese Communist
CINCPAC	Commander-in-Chief, Pacific Command
COMINT	Communications Intelligence
COMUSMACV	Commander, U.S. Military Assistance Command, Vietnam
CONUS	Continental United States
CofS	Chief of Staff
CSAF	Chief of Staff, United States Air Force
DF	Direction Finder
DMZ	Demilitarized Zone
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
ELINT	Electronic Intelligence
EOB	Electronic Order of Battle
EW	Electronic Warfare
EWLO	Electronic Warfare Liaison Officer
EWO	Electronic Warfare Officer
Frag	Fragmentary Order
GCI	Ground-Controlled Intercept
HF	High Frequency
IP	Initial Point
IRR	Immediate Reaction Report
JCS	Joint Chiefs of Staff
LOP	Line of Position
MACV	Military Assistance Command, Vietnam
MAW	Marine Air Wing
MEOB	Master Electronic Order of Battle
MHz	MegaHertz
mm	millimeter

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NM	Nautical Mile
NVN	North Vietnam
OPlan	Operations Plan
PECM	Passive Electronic Countermeasures
POL	Petroleum, Oil, and Lubricants
Psywar	Psychological Warfare
Recon	Reconnaissance
RHAW	Radar, Homing, and Warning
RTCC	ROLLING THUNDER Coordinating Committee
SAB	Scientific Advisory Board
SAM	Surface-to-Air Missile
SEA	Southeast Asia
SS	Security Service
SVN	South Vietnam
TACS	Tactical Air Control Squadron
TAR	Tactical Air Reconnaissance
TAWC	Tactical Air Warfare Center
TEW	Tactical Electronic Warfare
TEWS	Tactical Electronic Warfare Squadron
TFW	Tactical Fighter Wing
TOT	Time Over Target
USAFSS	United States Air Force Security Service
USMC	United States Marine Corps
USN	United States Navy
VC	Viet Cong

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