AD-A265 494

REPORT DOCUMENTATION PAGE

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 1992	3. REPORT TYPE AND DATES COVERED XXXXXX/DISSERTATION

4. TITLE AND SUBTITLE The Radar Eye Blinded: The USAF and Electronic Warfare, 1945-1955	5. FUNDING NUMBERS
6. AUTHOR(S) Daniel T. Kuehl, Lt Col	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AFIT Student Attending: Duke University	8. PERFORMING ORGANIZATION REPORT NUMBER AFIT/CI/CIA- 92-033D
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) AFIT/CI Wright-Patterson AFB OH 45433-6583	10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES	
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for Public Release IAW 190-1 Distribution Unlimited MICHAEL M. BRICKER, SMSgt, USAF Chief Administration	12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

14. SUBJECT TERMS	15. NUMBER OF PAGES 277
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

THE RADAR EYE BLINDED:

THE USAF AND ELECTRONIC WARFARE, 1945-1955

by

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Date: [illegible]

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Dissertation submitted in partial fulfillment of
the requirements for the degree of Doctor
of Philosophy in the Department of
History in the Graduate School
of Duke University

1992

ABSTRACT

At the start of World War II military electronics was in its infancy; by the end of the war electronic warfare (EW) had become a decisive arena of military operations. A key portion of this struggle involved the battle between radar and the various countermeasures (called radar countermeasures, or RCM, during the war, and electronic countermeasures, or ECM, since the 1950s) developed to negate enemy radar. The U.S. (Army) Air Force ended the war with a panoply of electronic weapons that encompassed virtually the entire electromagnetic spectrum and far outstripped German and Japanese systems. The focus of this study is on the ensuing decade: did the Air Force build on the developments and lessons of World War II and continue to improve and increase its growing ability to use ECM to support air operations, or did it permit this hard-won momentum to dissipate?

This study concentrates on the doctrinal and operational elements of the Air Force's use of ECM to support offensive combat operations. It does not directly address such factors as intelligence gathering or technology development except as they pertain to the primary topic. As a result, the study focuses closely on the activities of the Air Force's two primary combat commands, the Strategic Air Command (SAC) and the Tactical Air Command (TAC). The primary source of research material was the vast collection of unit records and organizational histories held by the Air Force Historical Research Agency (AFHRA) at Maxwell AFB, Alabama. Three important lesser sources were the Modern Military Records Branch of the National Archives, in Washington, DC.; the Association of Old Crows (the U.S. Electronic Warfare Association) archives, in Alexandria, Virginia; and the SAC

Office of History's archives, then located at Offutt AFB, Nebraska.

The first half-decade after the end of World War II saw the Air Force's EW capability seriously decline. This was caused principally by the rapid and essentially chaotic postwar demobilization that saw much of the Air Force's small core of EW expertise returned to civilian life, and most of the wartime equipment scrapped or sold for surplus. Other factors, however, also shaped this process; the technical demands for new equipment proved in many cases to be too daunting, as the Air Force tried to push technology to meet operational needs, and most of the Air Force was unaware of the potential EW offered for improved combat capability. By 1955 the Air Force was moving in divergent directions on EW. SAC pushed for improved EW capability and integrated that capability into its plans because its commander, General Curtis E. LeMay and his senior staff had used EW during World War II and knew its potential. SAC was making full use of it to the point of redesigning its new jet bomber, the B-52, around it; TAC, however, demonstrated little capability or interest in it, largely because of internal attitudes about the need for EW in tactical air operations.

ACKNOWLEDGMENTS

If I attempted to personally thank everyone to whom I am indebted regarding this dissertation, indeed my entire program at Duke, this section would take on the appearance of an Academy Awards presentation. But some deserve special thanks. Foremost among them are the staff at the USAF Historical Research Agency at Maxwell AFB, Alabama. In the mid 1970s it was my pleasure and good fortune to be a member of the staff there; my ego would like me to believe that the superb assistance I received while doing research there was because of the many friends I have that still work there, but in truth they treat all researchers with the same degree of concern and outstanding professionalism. To Judy Endicott, Lynn Gamma, Hugh Ahmann, Marv Fisher, and all the rest of the staff, my thanks unending. The staff at the Association of Old Crows, the US Electronic Warfare Association located in Alexandria, Virginia, kindly opened their archives and permitted me to make copious use of their photocopier to save research time. I hope that this study, in return, helps to further their educational efforts about the role and importance of electronic warfare. I am further indebted toUSAF Colonels (retired) Frank Lindberg (who passed away as this study was completed), Les Manbeck, Walter Stachura, and Hugh Winter, who patiently answered my questions, returned my calls, and replied to my letters, giving me the benefit of their knowledge of the Air Force's early days of EW, gained as pioneers in the crucible of war during the 1940s and 1950s. I also owe "big time" to my friend and comrade Lt Col Rob Owen, who read this manuscript and made several excellent suggestions.

I also wish to acknowledge a group of people who, although not directly connected with this dissertation, I will always remember with the affection and pride that comes from sharing both hardships and triumphs, Colonel John Warden and the rest of my comrades in "Checkmate" during the Gulf War of 1990-91. This dissertation had to go into hibernation for more than a year following Iraq's invasion of Kuwait in August 1990 because of my work, first during the crisis and conflict, and afterwards as part of several DoD and USAF "lessons learned" efforts. During the early stages of the crisis in late 1990 I was part of the "Checkmate" planning staff that first developed the concept for the air campaign employed against Iraq during the Gulf War, then provided round-the-clock support to the planners and operators in theater during January and February 1991. The two months immediately following the onset of the crisis were the most professionally rewarding time of my entire Air Force career; despite working 18 hour days for weeks on end, we knew that we were taking airpower another step. Being in "Checkmate" that first night of the war and watching the rabbit come out out of the hat exactly as planned was an unforgettable experience. My thanks to Colonel Warden for making me part of the team!

Last but certainly not least, I owe an unpayable debt of gratitude to my family: to my parents, who sent me off to school so many years ago and started me on the path that has led to this point; and to my wife and daughters, who have paid the price for my Air Force career. I get to go to new and exciting jobs, while they get to leave friends, churches and schools and move yet again. To Turkey, Alabama, California, North Dakota, Nebraska, North Carolina, and now Washington DC, they have gathered their things and followed me along. My wife, Susan, has always been there when needed to give encouragement, love, and the occasional nudge to keep at it. My daughter, Kimberly, has left a trail of schools and friends across the country; I can't make it up to her, but I can at least acknowledge the debt I owe her. Finally, Durham brought us another daughter, Dorian, who is just beginning to get the hang of this Air Force life. It's like the magnet on our refrigerator: "Home is where the Air Force sends you!" For three years we were blessed to call Durham "home"!

PREFACE

The genesis for this project was twofold. For the first suggestion of electronic warfare as a topic for major research I owe a nod of the head towards then-Major Dave Gessert, who first suggested it one day while we were both action officers on the staff at HQ SAC. When I then proposed it to my dissertation advisor, Professor (and Major General, USAFR, ret.) I. B. Holley, Jr., he was quite enthusiastic and noted that EW was a field waiting to be explored. As usual, he was right!

Some have asked how I chose the period; again, several factors played a part in setting the chronological bounds. First, Alfred Price and the Association of Old Crows had just published the first volume of The History of U. S. Electronic Warfare, which ended with the close of World War II; that left a natural starting point. Second, a ten-year span seemed like a manageable period that would include the postwar demobilization, the Korean War, and the start of the 1950s buildup. Third, all the pre-1955 records were more than thirty years old and thus subject to the "thirty year rule" regarding downgrading and declassification of classified records. This proved to be a wise decision, as I had very little difficulty getting large amounts of classified material summarily downgraded because of their age.

I approached the subject of electronic warfare from a doctrinal and operational rather than technological standpoint, for several reasons. First, I knew that when I left Duke I would be working in the doctrine office at the Air Staff, and I wanted to cast my work in a doctrinal mold. Second, the Air Force has a dozen technologists for every doctrine specialist, and I believed that I could make a greater long-term contribution to military story by examining the Air Force's development of EW from a doctrinal rather than technical position; we did not need, in my opinion, another study of how to produce technology or hardware. As a result, this study focuses on the operational aspects of EW rather than the research and development process of weapon system acquisition. Third, the "beeps and squeeks" aspects of EW can become very esoteric very quickly, and I wanted to produce a study that would be as widely useable and read as possible; I have tried to avoid (as much as possible) burying the reader in "megahertz" and "frequency bands", and have mentioned the technical side of EW only where it was necessary to understand an issue. The process of narrowing the focus to keep the project at a managable size meant that this study concentrates on the doctrinal and operational aspects of the offensive use of EW and ECM --- bombers and fighters using it to negate enemy radar. As a result, several interesting topics were not explored, including (but far from limited to) electronic intelligence (ELINT) gathering, the use of electronic counter-countermeasures (ECCM) by the Air Defense Command in the early 1950s, and the R&D process for EW equipment.

When this study was initiated the U.S. and Soviet Union held the world in a bipolar grip that dominated world strategy and politics. When this study was completed, changes so vast and sweeping had taken place that if someone had prophiseid them when I began my research, that unfortunate soul might have been locked away in an asylum! Yet the events of the intervening years in part validated some of my findings. When World War II ended the Air Force demobilized many of its key specialists, only to have to rebuild that capability. Just before the Gulf War, the Air Force proposed eliminating its force of F-4G "Wild Weasel" radar hunter-killers, only to find that during the war their availability was a "go/no-go" determinant for virtually every air operation I vividly recall watching planned air attacks be cancelled for lack of EW and SEAD (Suppression of Enemy Air Defenses) support. From another standpoint, the war reaffirmed the importance of command interest and support. After World War II, for example, only SAC actively supported EW, because its senior leaders saw the need for it. The TAC community, on the other hand, did not, a lack of vision which many pilots would rue dearly in Vietnam. The experiences of the Gulf War may serve to remind the Air Force that without critical capabilities such as EW and SEAD support our overall combat capability may be diminished by more than on the surface appears to be the case.

World War II ended with three revolutions in military technology that affected airpower: propulsion (jet engines), destructive firepower (nuclear weapons), and electronics (communications and radar). Postwar research on radar discussed the "new eye of radar" and the possibilities it offered for navigation and defense. The title of this study is taken from a reference by Vannevar Bush to the "new eye" of radar, for ECM is essentially anti-radar, thus blinding the radar eye.

Many people and organizations had a role in the preparation of this study, and if I have missed them in my acknowledgements I hereby apologize. One thing I must bear alone, however, is the responsibility for any mistakes or errors, and I wish to emphasize that the opinions and conclusions contained in this study are mine alone and do not reflect official endorsement by either the United States Air Force or the Department of Defense.

ILLUSTRATIONS

GLOSSARY

AAA	Anti-Aircraft Artillery
AAF	Army Air Force
ACC	Air Coordinating Committee
ACO	Air Communications Office
ACSC	Air Command and Staff College
ADC	Air Defense Command
AFB	Air Force Base
AFM	Air Force Manual
AFR	Air Force Regulation
AFSC	Air Force Specialty Code
AIR	Air Intercept Radar
AMC	Air Materiel Command
APC	Air Policy Commission
APGC	Air Proving Ground Command
ARDC	Air Research and Development Command
ATC	Air Training Command
AUQR	Air University Quarterly Review
AWC	Air War College
C3CM	Command-Control-and-Communications Countermeasures
CCB	Combined Communications Board
C-E	Communications-Electronics
CEI	Communications-Electronics Instructions
DCS	Deputy Chief of Staff
DF	Direction-Finding
DO	Director of Operations
EC	Electronic Combat
ECCM	Electronic Counter-Counter Measures
ECM	Electronic Counter Measures
ELINT	Electronic Intelligence
ESM	Electronic Support Measures
EW	Electronic Warfare
FEAF	Far East Air Forces
GCI	Ground Controlled Intercept
GLR	Gun-Laying Radar
HF	High Frequency
IR	Infrared
JCB	Joint Communications Board
JCEC	Joint Communications and Electronics Committee
JCS	Joint Chiefs of Staff
KT	Kiloton
LORAN	Long Range Navigation

MhZ	Megahertz
MOP	Memorandum of Policy
MOS	Military Occupational Specialty
NDRC	National Defense Research Committee
OSRD	Office of Scientific Research and Development
QRC	Quick Reaction Capability
R&D	Research and Development
RADAR	Radio Detection and Ranging
RCM	Radar Counter Measures
RRL	Radio Research Lab
RWR	Radar Warning
SAB	Scientific Advisory Board
SAC	Strategic Air Command
SACR	Strategic Air Command Regulation
SAG	Scientific Advisory Group
SAM	Surface to Air Missile
SEAD	Suppression of Enemy Air Defenses
SHORAN	Short Range Navigation
SIGINT	Signals Intelligence
SLC	Searchlight Control
STAG	Scientific and Technical Advisory Group
TAC	Tactical Air Command
UHF	Ultra High Frequency
USAF	United States Air Force
VHF	Very High Frequency
WAA	War Assets Administration
WSEG	Weapon System Evaluation Group

A Note on Equipment Terminology

The different letters used to designate US ECM equipment, such as AN/APT-4 or AN/ARQ-8 identified what type of equipment it was. The AN prefix meant that it was jointly used by the Army and Navy (thus AN); the first letter after the slash (/) identified the platform or carrier: "A" identified it as an airplane. The second letter identified the type of system: "P" meant radar, "R" meant radio, and "Q" meant countermeasures. The third letter meant the purpose: "T" meant transmitter, while "Q" meant special equipment. The number was a series designator.

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CHAPTER ONE

INTRODUCTION TO ELECTRONIC WARFARE

In the full flush of overwhelming victory in World War II the architects of American airpower looked to both the past and future with satisfaction and expectation: satisfaction that the theories of aerial warfare which they had been promulgating during the decade of the 1930s had been vindicated, and expectation that soon the Air Force would attain the long-awaited goal of independence as a separate service. Several technological revolutions had occurred, and the Air Force was ideally placed to exploit them. The advances in speed offered by jet propulsion, and the enormous increase in the destructiveness of bombardment with atomic weapons, seemed to mark airpower as the preeminent arm of America's future defenses. Overlooked by many, however, was a third technological revolution, that of electronics. Certainly everyone knew of radar, but far less well understood was the electronic war between radar and radar countermeasures (RCM) that had raged concurrently with the shooting war. Yet victory in this electronic war was crucial to the overall victory, and by the end of World War II the Air Force had developed and employed in combat a panoply of electronic weapons which spanned the electromagnetic spectrum and far outstripped the devices deployed by the Germans and Japanese. The focus of this study is on the ensuing decade: did the Air Force press forward energetically, pushing the technological limits outward and integrating electronic warfare (EW) into all aspects of Air Force plans and operations, or did it, in the heady aftermath of victory, neglect the hard-won electronic lessons of the war and permit the momentum it had developed to dissipate?

To answer that question adequately requires the examination of a wide range of topics which relate in some way to how the Air Force viewed and managed electronics during the late 1940s and early 1950s. What key decisions did Air Force leaders make about the EW program, and what factors shaped their decisions? How were the lessons learned during combat used to develop plans and equipment? What internal or attitudinal factors in the Air Force affected how EW was viewed and managed? How was it integrated into existing operational plans? Last but certainly not least, how was EW included in the doctrinal process? Was EW clearly an important factor in Air Force doctrine, or was it ignored?

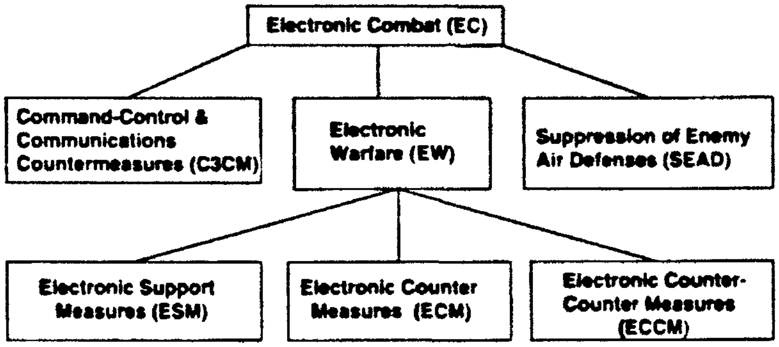
Terminology & Definitions

Electronic warfare is an admittedly esoteric field of conflict in which time-honored military terms such as "advance" or "retreat" have little meaning, so it is important to establish at the outset what some of the most commonly used terms mean. Electronic Warfare (EW), as defined by current (1990s) Air Force doctrine, includes those military actions designed to "...detect, deny, analyze, and hinder enemy use" of the electromagnetic spectrum.[1] This broad, overarching definition actually includes three more specialized tasks. Electronic Support Measures (ESM) embraces the critical function of Electronic Intelligence (ELINT), gathering information on the enemy's electronic capabilities. Electronic Countermeasures (ECM), called Radar Countermeasures or RCM during World War II, are those actions taken to jam or

[1]United States Air Force, Air Force Manual 1-1, "Basic Aerospace Doctrine", (Washington, DC: GPO, March 1992), Vol II, pp. 191-192.

deceive the enemy's radar devices, while Electronic Counter-Countermeasures (ECCM) comprises those actions taken to negate the enemy's ECM activities.[2]

Figure 1
Taxonomy of Electronic Warfare



This broad range of actions, which constitute EW in current Air Force doctrine, are themselves merely parts of an even broader field of conflict the Air Force terms Electronic Combat (EC), which involves "actions to protect friendly electromagnetic capabilities and actions to neutralize or destroy the enemy's".[3] EW is only the first of three component parts of EC. The second, Command-Control-and-Communications Countermeasures (C3CM, usually called "C-cubed" or "C-three" CM), includes those activities designed to attack enemy and/or protect friendly communications systems. The third, Suppression of Enemy Air Defenses (SEAD), is crucial to the task of conducting friendly air operations, and consists of efforts to neutralize, disrupt, degrade or destroy enemy air defenses. Although such activities have been critical to

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[2]Ibid, p. 3-7; Richard E. Fitts, The Strategy of Electromagnetic Combat, (Los Altos, CA: Peninsula Publishing, 1980), pp. 1,2,

[3]AFM 1-1, pp. 3-6.

successful air operations since World War I, the almost total dependence of modern air defenses on electronic and radar devices has resulted in SEAD evolving into a critical aspect of Electronic Combat.[4]

Radar Principles

Unless one understands the basic scientific principles on which radar and the associated countermeasures are based any discussion of EW could be confusing. Radar (which stands for RAdio Detection And Ranging) functions through echoes: a pulse of radio energy at a certain frequency is sent out by a transmitter, and if it strikes something solid, such as an airplane, it bounces back towards the sender, where a radio receiver tuned to the same frequency collects the reflected signal. Analysis of this signal can then provide important information to a defender. The time interval between when the pulse is sent and received indicates how far away the airplane is; the direction the pulse is received from reveals how high and what direction the aircraft is flying; and how quickly the reflected echo changes position tells how fast the target is moving. Radar sets operate over a wide range of frequencies, because some radio frequencies functioned better for gathering specific types of information. Early warning radars, for example, often use relatively low frequencies because although they are less precise they are harder to jam than higher ones. Radars used to direct anti-aircraft fire use higher frequencies because they fix the target's location

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[4]Edgar Ulsamer, "Battle of the Beams," Air Force, vol 69, #10 (October 1986), p. 67; Don E. Gordon, Electronic Warfare: Element of Strategy and Multiplier of Combat Power, (New York, NY: Pergamon Press, 1981), p. 5.

with more precision.[5] The frequencies in the electromagnetic spectrum have been divided into a series of frequency bands to facilitate their efficient use. Ranging from those useful for voice radio (commonly referred to as High, Very High, and Ultra High Frequency, or HF, VHF and UHF) through microwaves and into even higher frequencies, the portion utilized for radar is actually rather limited.[6]

The ability to locate objects at great distances is radar's greatest capability, but it is not without its vulnerabilities, and the cyclical battle of radar and the opposing countermeasures centers on these vulnerabilities. Radar's greatest weakness may be that the range at which the radar pulse can be detected is longer than the range at which a useful return of that pulse can be obtained. For example, if a given radar can detect aircraft at a range of 200 miles, an aircraft may be able to "hear" the radar at 300 miles and thus have the opportunity to evade or deceive it. The direction of the beam reveals its origin, and the aircraft may be able to fly around it, staying out of its range, or use intervening terrain (such as hills) to mask itself. The pulse rate and width of the beam reveals its range and ability to distinguish between individual aircraft in a group. The rate of scan tells what its purpose is: early warning, searchlight and/or anti-aircraft gun direction, or even missile control. The frequency indicates its capability as well as its vulnerability to jamming. The goal of an active

[5] David Park, "On the Carpet", (American-British Laboratory, Division 15, undated [World War II-era]), pp. 1-3; Fitts, Strategy of Electromagnetic Combat, pp. 17-18,

[6] Barry Miller, "US Girds for Survival in Electronic Warfare," Aviation Week, vol 96, (21 February 1972), p. 39

ELINT program is to gather intelligence on an opponent's radar devices so that effective electronic countermeasures equipment and tactics can be developed.[7]

The intent of all ECM is to prevent the enemy radar from obtaining useful information about the target aircraft, and there are several basic methods by which this is accomplished. The first and least complicated is simply to avoid the radar, but this will not be feasible in many cases. The next tactic is to surround the object of the radar's search with other objects so that the radar cannot distinguish which returning signal is from the target aircraft. Decoys can accomplish this, but the most common technique is the use of confusion reflectors, called chaff. First used in World War II, chaff consists of thin strands of metal or wire, cut to the wavelength of the enemy radar signal. When a few pounds of chaff are released from an aircraft the effect on a radar can be dramatic, with the display screen suddenly filled with thousands of radar returns. The intent of chaff is to dilute or degrade the enemy radar network so that it presents an incomplete and misleading picture of the aerial situation.

This is also the intent of active countermeasures such as electronic jamming, which attempt to obliterate the radar return in a "hash" of spurious signals. There are two general types of jamming, saturation jamming, which attempts to overwhelm the radar receiver with stronger signals, and confusion/deception jamming, which attempts

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[7]James Phinney Baxter III, Scientists Against Time, (Boston: Little, Brown & Co, 1946), p. 162; Alfred Price, Instruments of Darkness: the History of Electronic Warfare, (London: Macdonald & Janes, 1977), pp, 255-56; Joint Board on Scientific Information Policy, Electronics Warfare: a Report on Radio Countermeasures, (Washington, DC: GPO, 1945), p. 3.

to deceive the radar receiver with spurious signals that mislead the radar as to the target's range, etc. The final method is the most certain: actual destruction of the enemy radar. First attempted in World War II, this tactic came to fruition during the Vietnam War with the development of the Wild Weasel radar hunter-killer aircraft, which is a key element of current SEAD operations, as clearly demonstrated during the Desert Storm air campaign against Iraq.[8]

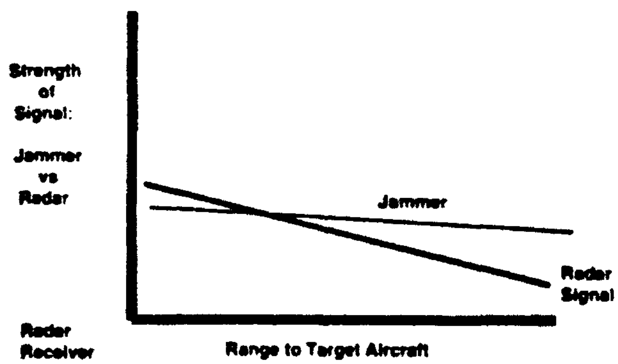
Electronic Countermeasures

This study concentrates on the offensive employment of ECM by aircraft such as bombers and fighters; other aspects of EW, such as communications security, ELINT, Electronic Counter-Countermeasures (ECCM), or the use of ECM for air defense, will be addressed only as they touch upon the primary topic. It would be useful, therefore, to explain more fully some of the principles, tactics and techniques employed in ECM operations. Chaff is used against radar by creating new and misleading targets, or by concealing the real target; in either case, the intended effect is to confuse and delay the defense so that it cannot effectively respond (ie. shoot down the aircraft). The most common forms of chaff are the small wire and/or aluminum strips cited earlier. Another form is called rope, which is simply strands of the reflective material wound into lengths and designed to block the lower radar frequencies. The effectiveness of chaff is dependent on several variables: the frequency of the radar, the weather

[8]Fitts, Strategy of Electromagnetic Combat, p. 79; Park, "On the Carpet!", p. 7; USAF, AFM 51-3; Electronic Warfare Principles, (Washington, DC: GPO, 1962, superceeding a 1955 manual on the same subject), pp. 5-1 through 5-5.

conditions (wind disperses the chaff, moisture affects its reflectivity, etc), rate of fall of the chaff strips, the speed and altitude of the aircraft dropping it, and others. Despite its simplicity, chaff remains one of the most effective and certainly cost-efficient ECM devices.[9] Radar jamming is the second major means of ECM employment, and as previously mentioned jamming can consist of either saturation or confusion/deception operations. In all cases, jamming derives its effectiveness from the fact that the radar receiver must be extremely sensitive, in order to pick up the faint reflected signal, and thus is vulnerable to a jammer that can send a more powerful signal to the receiver.[10] Thus, until the aircraft gets close to the radar, its jammers may be able to overpower the radar receiver, as in the following chart:

Figure 2
Power vs Range



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[9]Ibid, pp. 5-2 through 5-4; Fitts, Strategy of Electromagnetic Combat, pp. 87-88.

[10]This chart is a simplified version depicting the result of an actual test in 1949 of an AN/CPS6 radar vs a B-29 bomber employing current jammers. The test perfectly illustrated the fact that the jammer need not be as powerful as the radar, only strong enough to overpower the weak return. The jammer, broadcasting at 25 watts spread over a frequency bandwidth of 5 megacycles, screened the bomber from a radar broadcasting at 750,000 watts until the B-29 was about 15 miles away. "Summary of Minutes. Air Force--Industry Conference", 20 May 1949, remarks by Mr. Collbohm, from the RAND Corporation.

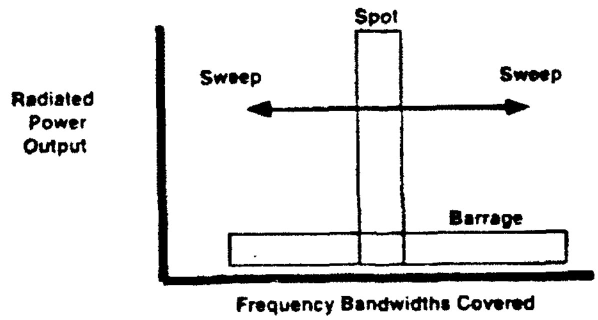
There are a few basic techniques employed in saturation jamming. The first, spot jamming, concentrates all of the jammer's radio power on a specific frequency or narrow band of frequencies. The advantage is that the jamming signal is thus very likely to be much stronger than the radar return: if the return signal is within the frequencies covered by the spot jammer, it is likely to be completely blotted out by the jammer. This technique does have several disadvantages, however, the greatest of which is that it can only cover a very small bandwidth of frequencies, and one aircraft may not be able to carry enough spot jammers to cover all the radars that it may encounter. Another disadvantage is that this technique requires a trained operator to determine when and how the equipment should be used. This sets the stage for the model EW battle: the radar operator switching frequencies to avoid being jammed while the ECM operator "looks through" his transmissions and tries to keep his jamming signal on the same frequency as the radar.[11] The second technique, barrage jamming broadcasts a jamming signal across a wide bandwidth of frequencies. Its chief advantage is that the operations planner needs only relatively generalized intelligence about the enemy radars, and a large strike force employing many barrage jammers can effectively blanket a large portion of the frequency spectrum. An added advantage is that this technique does not require large numbers of trained operators, merely someone to activate the jammers at the planned time or place. These advantages must be weighed against several disadvantages, chief of which is that by

[11]AFM 51-3, pp. 5-9; Park, "On the Carpet", p. 10.

dissipating the jammer's signal across many frequencies the power applied against each is reduced and thus may not effectively degrade the enemy radar. Another disadvantage is that unless a large number of jammers are employed to provide overlapping coverage in depth, the loss of even a few jammers may leave wide gaps in the ECM coverage, thus negating the entire effort and jeopordizing the mission.[12]

A third technique, called sweep jamming is a hybrid of spot and barrage jamming in which the jammer is rapidly tuned across a range of frequencies so that at any particular moment all of its power is concentrated on a narrow bandwidth. The advantage of this technique is that it can cover a wide range of frequencies with a great deal of power applied to the jamming signal. The accompanying chart illustrates the power and frequency coverage differences between spot and barrage jamming.

Figure 3
Barrage, Spot & Sweep Jamming



The disadvantages that accompany sweep jamming, however, are important. The technological requirements imposed on the development of such a jammer are

[12]AFM 51-3, pp. 5-9, 10; the chart is an adaptation of Figure 5-1 in this manual; Baxter, Scientists Against Time, p. 166; Park, "On the Carpet", p. 11.

complex. It must perform difficult tuning changes rapidly, to keep the enemy radar jammed, yet prevent reacquisition of the tracking signal during the time when the jamming signal is "swept" to another frequency. Sweep jammers were initially designed for unattended use in aircraft unable to carry an ECM operator, such as the B-47 bomber.[13] Confusion/deception operations concentrate more on fooling the enemy radar than on blocking it. Jammers can be designed to exploit certain electronic characteristics and vulnerabilities of radars so that the radar operator receives a distorted and false return. For example, a multiple target generator makes one aircraft appear to be many, while a range-gate stealer feeds incorrect range information to the radar. Both would be very effective tactics to use against a radar-guided surface-to-air missile (SAM). Confusion/deception ECM systems are far more efficient in the use of their radiated power than are the saturation systems, which use brute electronic force to overwhelm the enemy radar. They are also far more complex, however, and to develop these devices in small, reliable packages poses a much more difficult technological problem than simply building a transmitter that will match the frequency of a given radar. As will be seen, the problem of miniaturizing EW equipment has been a persistent one that has significantly effected the combat capability of a series of USAF aircraft.[14]

Current Doctrine and EW

[13]AFM 51-3, p. 5-10; Chapter 8 of this study contains a fuller discussion of the B-47 and its ECM suite.

[14]Ibid, p, 5-10

An effective EW capability is virtually a necessity for modern air warfare, as demonstrated during the past two decades. In operations involving heavy bombers (e.g, B-52s in Linebacker II over Hanoi in 1972), close air support by land-based tactical aircraft (e.g. the Middle East during the 1973 Yom Kippur War), air superiority operations (e.g, 1982 over Lebanon's Bekaa Valley, in which superlative Israeli ELINT led to the Syrian Air Force being savaged by Israeli fighters), or fleet defense by naval aircraft (e.g. the Royal Navy's Harriers during the 1982 Falklands War), successful aerial operations would have been impossible without effective EW. The EW and SEAD operations conducted during the Desert Storm air campaign were "essential" to its overall sucess. Current USAF doctrine is fully cognizant of the crucial role played by EW: each of the various missions for air forces outlined in Air Force Manual (AFM) 1-1 "Basic Aerospace Doctrine" would be virtually impossible without EW.[15] AFM 1-9, "Doctrine for Electromagnetic Combat", stated at the outset "EW has often been treated as a peripheral kind of activity in the past, usually on an ad hoc basis...It must be transformed into a well-planned and integral part of our systems capabilities, of our military doctrine, and of our training."[16] Current doctrine

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[15]AFM 1-1.; Office of the Secretary of Defense, Conduct of the Persian Gulf War: Final Report to Congress, (commonly known as the "Title V Report"), April 1992, p. 217. The course of the Desert Storm air campaign is perhaps the best demonstration of how critical EW has become, for many missions could not have been mounted without the suppression of Iraqi air defenses, and there were cases of planned attacks being cancelled because no "Wild Weasel" (radar hunter-killer) support was available.

[16]USAF, AFM 1-9, Doctrine for Electromagnetic Combat, (Washington, DC: GPO, 18 September 1979, p. 1-1; the quote is from Dr, Malcolm Currie, Director of Defense Research and Engineering, 1976.

as stated in AFM 2-8, "Aerospace Operational Doctrine - Electronic Combat Operations", expands upon the basic doctrine to state that "Commanders must understand EC' s potential, employ EC as a weapon, and train with EC", and recognizes that EC strategy has elements common to all Air Force operations. In short, EW's criticality cuts across the board: a great deal of the Air Force's ability to conduct combat operations and carry out its mission depends on its ability to conduct effective and successful EW operations.[17]

Summary

This study will attempt to determine whether or not the USAF continued to develop its Electronic Warfare capability after World War II, and will focus on the ability of the Air Force to conduct airborne offensive Electronic Countermeasures operations. Having briefly examined the terminology of EW and the basic scientific principles on which EW functions, as well as its basic tactics, techniques and doctrine, the next step is to examine the beginnings of EW: how it became a weapon of war.

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[17]USAF, AFM 2-8, Aerospace Operational Doctrine--Electronic Combat Operations. (Washington, DC: GPO, 30 June 1987), pp. 3, 4.

CHAPTER TWO

THE EARLY YEARS THROUGH WORLD WAR II

At the outset of World War II radar, still little known among American airmen, was a scientific marvel, with potential capabilities and vulnerabilities largely unexplored. Shortly after the United States entered the war the War Department greatly expanded its research and development programs for radar and potential countermeasures to it, aided by the British, who had been sharing technical secrets since early in the war. This marked the start of a tremendous scientific and engineering effort. By the end of the war the Air Force had integrated the use of radar countermeasures into heavy bomber operations against Germany and Japan, developed an extensive Electronic Warfare capability, and identified several critical future needs. But no institutional mechanism had been developed to insure that suitable doctrines were devised and research programs established to exploit more fully the military potential of electronics. As a result, the impetus provided by wartime necessity waned: progress not only halted, the Air Force actually regressed.

Setting the Stage

The earliest known use of radio countermeasures dates to the first decade of the 20th Century. In 1902 and 1903 the Royal Navy and US Navy both attempted during their annual manuevers to jam radio signals by transmitting "on top" of the signals to be jammed. In April 1905 the first combat use took place, during the Russo-Japanese War, when a Russian radio operator used his spark transmitter to jam Japanese signals being used to correct naval gunfire. During World War I radio jamming and signals intelligence (SIGINT) were important factors in several naval engagements, including the escape of the German warships *Goeben* and *Breslau* across the Mediterranean Sea in August 1914 (which contributed to Turkey's entry into the war), and the Battle of Jutland in 1916. Although these featured countermeasures to radio and not radar, they indicated that the military was becoming increasingly aware that electronics would play a role in warfare.[1]

Radar was first tested in England in 1935, and by the end of that year the British began studying the feasibility of establishing a line of radar sites along their coast, that became the Chain Home early warning system. At the same time, they began to study the possibility that this system could be jammed, and by 1938 they were testing jammers against their own radars. The value of the Chain Home system was evident in 1940: without its early warning of Luftwaffe attacks, it is doubtful that the RAF could have won the Battle of Britain. The value of the jamming trials was also apparent, if much less well known, and Britain's superior jamming technology was a critical factor in its victory in the "Battle of the Beams" during The

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[1]Alfred Price, The History of US Electronic Warfare, Volume I: The Years of Innovation - Beginnings to 1946 (hereafter referred to as History of US EW), (Westford, MA: Association of Old Crows, 1984), pp. 4-5; David G. Chizum, Soviet Radio Electronic Combat, (Boulder, CO: Westview Press, 1985), p. 2; The first use of RCM during US Navy manuevers offered a perfect illustration of the problem of signals intelligence vs jamming: a young US Navy signalman started to jam a signal from the opposing fleet when a lieutenant stopped him, saying that he wanted to get the signal first. When it was done he instructed the signalman to "Now make interference." The signalman's reply, "I can't...its gone out at 186,000 miles per second and no one on Earth can stop it!" was a bit impertinent (he got sent to the brig!) but also accurate.

Blitz.[2]

Work on the development of offensive jamming systems proceeded along two lines. The more complicated of the two, the development of a transmitting system to jam German radars, rested on Sir Henry Tizard's invention of the Cavity Magnetron, which made the construction of a radar-jamming transmitter possible. The cooperation between Tizard and other British and American scientists and electronics experts was probably the primary factor in the rapid development of EW technology by the two nations. German technology in this area never approached that attained by the two great Atlantic allies. Work on the second line, radar confusion reflectors (chaff), had been initiated in the late 1930s, and both Britain and Germany saw its potential usefulness. But while the British successfully developed (in great secrecy) an operational chaff capability, the Germans forbade any further work, in fear of what might happen should the British learn of it. As a result, when the RAF first employed chaff in combat in July 1943, the Germans were caught totally by surprise. The Luftwaffe's night defense force could only watch helplessly while Hamburg fell victim to the world's first firestorm and 40,000 people perished. By mid-1943, then, the battle between radar and countermeasure was well underway, with several key

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[2]M. T. Thurbon, "The Origins of Electronic Warfare", Journal of the Royal United Services Institute for Defense Studies (hereafter cited RUSIJ) 122, (September 1977), p. 56; Price, History of US EW, vol I, p. 10; For the two best accounts of EW in Europe see R. V. Jones, Most Secret War, (London: Coronet), 1978; and Price's earlier work, Instruments of Darkness; The Battle of the Beams and the Blitz offered one humorous example of popular misunderstanding about EW. A sincere if not-too-scientifically-minded Londoner suggested that the way to find German bombers at night was to "Take cat in airplane: aim guns where cat is looking"!

victories scored by the British.[3]

On the Homefront

The effort to establish an American EW capability dates to 27 June 1940, when the National Defense Research Committee (NDRC) was formed under the guidance of Dr. Vannevar Bush. Reporting directly to President Roosevelt, the NDRC's charter was to marshall American science in support of national defense. A few months later the NDRC centralized all radar research by forming the Radiation Laboratory at the Massachusetts Institute of Technology (MIT). At this point no thought had been given to developing an anti-radar capability, but four days after the Japanese attack on Pearl Harbor a joint meeting of the NDRC, Navy, Office of Scientific Research and Development (OSRD) and the Radiation Lab itself led to forming a division of the NDRC whose sole responsibility would be the design and development of ECM devices. Division 15 of the NDRC was formed under the guidance of Dr. C. Guy Suits, who quickly set about establishing a facility devoted to research and development of countermeasures. Dr. Fred Terman, head of the Electrical Engineering department at Stanford University, was selected as the first (and only) head of the division's own research lab. By early 1942 he had started recruiting personnel (many of them his ex-students) and by July 1942 he found a home for the Radio Research Laboratory (RRL) at Harvard. By then over 150

[3]Wilfred Eggleston, Scientists at War, (New York, NY: Oxford Press, 1950; Geoffrey Bennett, "The Development of the Proximity Fuze", RUSIJ, 121, #1 (March 1976), pp. 59-60; Charles B. Ablett, "Electronic Warfare: a Modern Weapon System", Military Review, XLVI, #11 (November 1966), p. 9.

people were working on ECM at the RRL, which continued to provide equipment to the Army, Navy, and Army Air Force for the rest of the war.[4]

While the RRL produced equipment in the lab, the field testing of that equipment was done by the 1st Proving Ground Electronics Unit (PGEU) at Florosa Field, one of the satellite installations at what is today Eglin Air Force Base on the Florida panhandle. Throughout the war the 1st PGEU, in cooperation with the RRL and Wright Field's Aircraft Radio Laboratory, tested equipment, trained personnel, and evaluated enemy equipment. One of the most important efforts which the 1st PGEU undertook led to the publication in December 1943 of the "Countermeasures Program for the Strategic Air Forces in the European Theater", which stated that the essential elements for the ECM campaign against the Luftwaffe would include Ferret aircraft for ELINT gathering, and airborne jammers and chaff dispensers for the bombers.[5]

The RRL and 1st PGEU did the research and development (R&D) work on ECM equipment, but there were two other major stateside elements in the ECM program.

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[4]Price, History of US EW, vol I, pp. 13-30; George R. Thompson, and Dixie R. Harris, The Signal Corps: the Outcome, a volume in the series The US Army in World War II, (Washington, DC: the GPO and US Army Center for Military History, 1966, p. 305; Henry E. Guerlac, Radar in World War II, volume 8 in the series The History of Modern Physics; 1800-1950, (American Institute of Physics, Tomash Publications, 1987), pp. 299-300; Frank Voltaggio, "Origins of ECM in the Air Force", Journal of Electronic Defense V, (June 1982), pp. 34-35.

[5]Air Proving Ground Command (APGC) history, Vol I, 1939-45, Air Force Historical Research Agency decimal 240.01-10 (these will hereafter be cited by their organization, date, and decimal); Price, History of US EW, vol I, pp. 86-87; APGC history, 1939-45, "Testing of Radar/Radar Equipment" Vol 3, 240.04-10 (document 6 is the report itself). Although neither the RRL nor the 1st PGEU survived the war, Eglin's role as the primary location for ECM field tests not only survived but expanded.

The first of these was the ECM school at Boca Raton, Florida. To say that the ECM training program started from scratch is an understatement: the Air Force in 1942 had very few men knowledgable in radar, let alone what amounted to anti-radar. The ECM training course began as an offshoot of the radar training program at Boca Raton. One of the cadre of instructors there was a young officer, Second Lieutenant Hugh Winter. His story is typical of many of the Air Force's earliest ECM operators: an engineer for a radio station before the war, he was hired as a civilian instructor in late 1941 and hurriedly commissioned in early 1942 after the start of the wartime emergency. Some of the other civilian instructors at the Air Force's radio school decided to remain civilians, while others were commissioned in grades ranging from second lieutenant to captain. The significance of this is that none of the men who would form the Air Force's cadre of ECM expertise during the war came from within the service: they were young technical experts who had backgrounds in science, engineering or radio, not military operations. Although this worked well for the immediate emergency of the war, it worked poorly for the long term: as will be seen, the Air Force's ECM expertise was decimated by the postwar demobilization, because the technical experts who were commissioned during the war were among the first to leave the service after the war.[6]

[6]Voltaggio, "Origins of ECM in the AF", pp. 34-42; Personal letters to the author from Lester Manbeck (Colonel, USAF, Ret), 31 March 1989; and Hugh Winter (Colonel, USAF, Ret), 15 March 1989; Assistant Chief of Staff/A-3 (Operations) and Deputy Chief of Staff/Operations, "Organizational and Functional History of A-3 in Army Air Force Headquarters", 1 July 1939- 2 September 1945, Vol I, pp. 106-108, 143.01 in AFHRA.

The ECM training course produced its first four graduates in November 1942. It was so highly classified that it was simply called "Hugh Winter's course", and to keep from mentioning the classified term "Radar Countermeasures" they were called "Ravens", from the codeword for RCM. Carrying an official title of "Aircraft Observer (Radio Observer)" and a military occupational specialty (MOS) of "7888, Radio Officer", these first few graduates were the cornerstone ' the Air Force's wartime ECM program. The total wartime production of officers trained in RCM was only about 600, small when compared to the millions of men trained by the armed forces during the war, but their level of training and technical expertise was unusually high and represented an asset whose value was disproportionate to its small numbers.[7]

The other major element in the ECM program was the establishment of an ECM staff element at Air Force headquarters in the Pentagon. As with the training program, this was an outgrowth of the increasing importance of radar. In January 1942 the Air Communications Officer (ACO) established a radar branch at Headquarters, Army Air Forces. One of the first three officers assigned there was a young scientist at the Radiation Lab at MIT who held an Army Reserve commission and was ordered to active duty. Second Lieutenant Mel Jackson was in many ways

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[7]Voltaggio, "Origins of ECM", p. 43; Harry F. Smith (Colonel, USAF, Ret.), "The History of Electronic Warfare: or, When the Old Crow was a Fledgling", <u>Crow Caws</u>, I (September 1966), p. 6; During the war ECM operators were called "Ravens", which is a common British term for crow. Although the exact origin of the name "Old Crow" is uncertain, it almost certainly is an Americanization of the term "Raven", thus the name "Association of Old Crows", which is the US Electronic Warfare Association.

similar to High Winter. Jackson had received a Master's Degree from MIT in June 1941, then joined the Radiation Lab staff. Although his Reserve commission was in Ordnance he quickly became the Air Staff expert on ECM, and by 1943 he headed up the Countermeasures Section in the ACO chain. By then Mel Jackson was Major Jackson; he and Hugh Winter were two of the three junior officers who comprised the rest of this small office.[8]

The ECM section was the Air Force focal point for a variety of activities related to countermeasures. It served as the Air Force technical representative on Joint (Army-Navy-Air Force) and Combined (US-British) committees dealing with ECM, established allocations and priorities for equipment for the combat forces overseas, and worked with the OSRD and NDRC Division 15 (Dr. Terman's RRL) on the R&D and testing of equipment. Its relations with the rest of the Air Staff were colored by the general lack of knowledge about countermeasures. As Hugh Winter described it, "we were a pretty isolated group...partly because nobody else had any understanding of RCM."[9] The very high classification of ECM also contributed to its isolation: the earliest ECM officers served as operators, planners, maintainers, and a host of other functions, in part because the equipment and its capabilities were so

[8]Voltaggio, "Origins of ECM", pp. 36, 42-44, which contains the full story of the Boca Raton radar and ECM school; ACS/A-3 History, 1939-45, 143.01, p. 108; Letter to author from Hugh Winter, 15 March 1989.

[9]Winter letter to author, 15 March 1989.

highly classified.[10] Another factor which influenced the development of ECM was its organizational placement within the Air Force. Since ECM was an outgrowth of radar it was logical that ECM remained with radar as a function of the Air Communications Office, which handled communications and electronic equipment. Yet radar was not a true communications device, and ECM even less so: they were not pieces of accessory equipment (such as a radio or altimeter) but critical aspects of the aircraft's combat capability, as vital to mission success as the aircraft's defensive armament or bombload. While it might be unfair to criticise Air Force leaders for not seeing this early in the war, the placement of ECM within the Communications field severely hampered its postwar development. In part this was due to the confused state of Communications, which underwent repeated organizational changes between 1941 and 1945. During most of this time Communications was viewed as a form of technical service, which hampered efforts to integrate ECM into combat plans and operations more closely.[11]

Much of this was not yet apparent in 1942 and 1943, of course: what was

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[10]Probably because of its highly technical nature, EW stills commands an air of secrecy: in 1988 one Air Force security manager felt that he could not declassify a document "because it dealt with electronics". Fortunately, HQ TAC determined that it should have been declassified much earlier.

[11]Chase C. Mooney and Edward C. Williamson, Organization of the Army Air Arm, 1935-1945, (USAF Historical Study #10, Maxwell AFB, AL: USAF Historical Division, Research Studies Institute, 1950, pp. 40, 53-54; ACS/A-3 History, 1939-45, 143.01, pp. 111-114; both in AFHRA. The tendency to view Communications as a technical, non-operational function was perhaps not surprising, since Communications "came from" the Army's Signal Corps, which is not traditionally viewed as one of the combat arms.

visible was that the Air Force had taken major steps in three directions towards developing a capability to employ ECM in combat. The work of the Radio Research Lab (RRL) was harnessing the background technology and industrial capacity of the US; the ECM section at the Air Staff was coordinating the farflung efforts of the ECM community; and the training program at Boca Raton was providing men to use the equipment to conduct electronic warfare. What remains to consider is the combat record ECM established during World War II. A detailed examination is not required: Alfred Price's several works have done that. But a brief survey of events in Europe and the Pacific is necessary set the context for the primary focus of this study.

ECM in Combat: Europe

The Germans entered World War II among the world's leaders in radar technology, and despite the advances made by the Allies, by the time large-scale American bombing operations started in 1943 the combination of German radar and air defense weaponry made the skies over Central Europe unfriendly indeed for Allied airmen. The Luftwaffe's defensive problem against the Royal Air Force's nighttime raids was different from that posed by the American daylight precision bombing campaign. Against the RAF the Luftwaffe had to locate at night individual bombers flying in a loose "stream". Several techniques were developed to locate and shoot down the bombers, all of which depended on radar. "Freya" early warning radars gave warning that a raid was in progress. Radar-guided searchlights then attempted to illuminate bombers so that night fighters and/or anti-aircraft artillery (called Flak, from the German Fliegerabwehrkanon; today it is more commonly known as AAA or "triple A") could engage the bombers. Radar used for this purpose was known as searchlight control (SLC) radar, although it was essentially the same as that used for gun-laying radars (GLR). Using radar in a technique similar to that used to guide commercial airliners today, Luftwaffe controllers on the ground would attempt to guide their night fighters to a position where they could find and attack a bomber. This was called ground controlled intercept (GCI), and it was greatly facilitated if the night fighter had its own airborne intercept radar (AIR), such as the "Lichtenstein", thus enabling it to find the bomber faster and from farther away. Although German Flak was used at night, it never recovered from the July 1943 disaster at Hamburg, when the RAF used chaff for the first time, and the primary threat to the RAF was always the Luftwaffe night fighter force.[12]

The Luftwaffe faced a different operational problem against the American bombers because during the day there was never any significant difficulty for Luftwaffe fighters in finding the massed formations of B-17s and B-24s. The problem was that after early-to-mid 1944 they also found swarms of American escort fighters, which proved to be so effective that after mid-1944 the primary threat to the bombers came from German Flak.[13] Thus the primary radar system which the

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[12]Stephen R. Fraley, (Major, USAF), "Electronic Combat Over the Third Reich", (unpublished thesis, Air Command and Staff College (ACSC), Air University, Maxwell AFB, AL: 1988), pp. 7-23.

[13]This does not mean that the Luftwaffe was impotent after early 1944: if the German fighters got through the screen of American escorts the results could be

Americans had to negate was the "Wurzburg" GLR, which provided much more accurate AAA fire than did visual aiming, because it was unaffected by those elements which degraded visibility, such as clouds, smoke and haze.[14]

The development of an electronic warfare capability in the 8th Air Force began in October 1942 with the formation of the Operations Research Section, which included a subsection on radar and radio countermeasures. In April 1943 this small group was further subdivided when Mr. Kenneth A. Norton arrived to head a subdivision on radio countermeasures. Wi.hin a month of his arrival, Norton recommended a series of actions to reduce 8th Air Force vulnerability to German radars, including equipping every bomber with a radar warning receiver and a jamming capability. His foresight was remarkable, given that these recomm ndations were published when the greatest threat to 8th Air Force bombers came not from flak but from the Luftwaffe's day fighter force.[15] Not until October 1943 did the 8th Air Force begin using using EW, with a test of its admittedly limited capability.

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devastating for a localized group of bombers.

[14]8th Air Force Operational Analysis Section, "Operational Considerations in Anti-Flak RCM Planning", 3 May 1945, 520.907, in AFHRA; NDRC Division 15, "War in the Ether: Operational Radar Countermeasures in World War II", undated, pp. 48-50; 8th AF Operational Research Section, "Flak RCM in the ETO - a Review and Evaluation of their use by the 8AF", no date, pp. 27-30, both in Association of Old Crows (AOC) Archives, Alexandria, VA.

[15]Charles W. McArthur, Operations Analysis in the U.S. Army Eighth Air Force in World War II. Vol. 4 in the History of Mathematics, (Providence, RI: American Mathematical Society, 1990), pp. 42-45; Norton had been the assistant director of the propagation unit, Operational Research Staff, Office of the Chief Signal Officer, US Army, Washington DC.

Between the 8th and 14th of the month the 8th Air Force flew four missions (against Bremen, Gydnia, Munster and Schweinfurt) in which aircraft in the 96th and 388th Bomb Groups carried APT-2 "Carpet I" barrage jammers while the rest of the bombers had no ECM protection. Although the primary threat from the Luftwaffe at this time was its fighter force, against which the jammers had no effect, operations analysis seemed to indicate that the jammers helped: the units equipped with them suffered about 5% fewer losses than did the rest of the force (14 lost out of 186 sorties, 7.5%, vs 134 lost out of 1066 sorties for the unprotected force, 12.6%. This factor was even more apparent in the analysis of flak damage to the bombers. On the 8 October mission to Bremen and Vegesack (on which 30 bombers were lost), for example, some 40 bombers of the 3rd Air Division carried Carpet I jammers, while the First Air Division had none. Flak damage in the Third Division was 15% lower than in the First Division.[16]

From this small but promising beginning the 8th AF continuously expanded its EW capability. Although the Carpet I jammer had relatively little power and was in short supply, it was effective enough to warrant increasingly widespread use, and

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[16]Price, History of US EW, vol I, p. 82; Roger A. Freeman, Mighty Eighth War Manual, (London: Janes 1984), pp. 97, 242; McArthur, Operations Analysis in the U.S. Army Eighth Air Force in World War II, pp 71-72; The different letters used to designate US ECM equipment, such as AN/APT-4 or AN/ARQ-8 identified what type of equipment it was. The AN prefix meant that it was jointly used by the Army and Navy (thus AN); the first letter after the slash (/) identified the platform or carrier, so "A" identified it as an airplane. The second letter idenfied the type of system, so "P" meant radar, "R" meant radio, and "Q" meant countermeasures. The third letter meant the purpose: "T" meant transmitter, while "Q" meant special equipment. The number was a series designator.

8AF implemented a policy of equipping two bomb groups in each combat wing with Carpet jammers. In December 1943 8AF used chaff (usually referred to as "Window", its code name) for the first time, and its use increased steadily. In February 1944 the bombers dropped 40 tons of it: by May use had increased ninefold, to 355 tons, by October to over 1000 tons, and it kept going up. One chaff tactic required the leading combat wing to drop chaff from four minutes before reaching the target until three minutes afterwards. Each bomber carried about 500 units of chaff, and the radio operator dispensed some several times a minute. This created a chaff corridor about twenty miles long, designed to shield the bombers from AAA during their bomb run, the most vulnerable part of the mission. Eventually, as the threat from German fighters lessened, the tight combat box formations were opened, to decrease the vulnerability to Flak.[17]

The last three months of 1944 saw a large expansion of the RCM subsection within the Operations Research Section, and they produced a stream of reports and suggestions for improving the 8th Air Force's EW capability. By early 1945 it had developed an extensive EW capability and was employing it daily in combat. Almost three-quarters of 8AF bombers had two APT-2 barrage jammers installed, whose pre-set frequencies were updated on weekly on the basis of ELINT intercepts. Each bomb group had several aircraft equipped with APQ-9 "Carpet III" spot

[17]Price, History of US EW, vol I, pp. 83, 99, 168; Kenneth P. Werrell, "The Tactical Development of the Eighth Air Force in World War II", (unpublished PhD Dissertation, Duke University, Durham, NC: 1969), p. 228; Fraley, "Electronic Combat Over the Third Reich", p. 7.

jammers and carrying an ECM operator. If used skillfully, six spot jammers could obtain results as good as or better than eighteen barrage jammers.[18] Additionally, the 8AF had formed a special squadron, the 36th Bomb Squadron (Radar Countermeasures), to conduct special jamming operations. Its primary mission was to deny accurate early warning information to the Germans, and it used a variety of communications jammers, such as the APT-3 "Mandrel" and APT-1 "Dina", to disrupt German voice communications and fighter control links. Until December 1944 most of its work was in support of RAF Bomber Command, but by early 1945 the 36th Bomb Squadron was engaged primarily in screening 8AF operations.[19]

How effective was EW in the air war against Germany? The question can be examined from two perspectives: that of the participants themselves (both German and American), and from a statistical analysis. Those German officers who had encountered American ECM were emphatic in their assessment that ECM had seriously degraded the effectiveness of their radars. A group of Flak officers in Italy told American interrogators after the war that ECM had made their Wurzburg flak-

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[18]McArthur, Operations Analysis in the U.S. Army Eighth Air Force in World War II. pp. 256-57; Price, History of US EW, Vol I, pp· 102-103; Werrell, "Tactical Development of the Eighth Air Force in World War II", pp. 226-230; Freeman, Mighty Eighth War Manual. pp. 97, 242; Memo, VIII Bomber Command to 2nd Bomb Division, 7 April 1944, Subj: "Operational Use of Carpet-Blinker", 526.907, in AFHRA; the 36th Bombardment Squadron (RCM) was activated after the 803rd Bombardment Squadron (RCM) was deactivated. See Freeman, The Mighty Eighth, (New York, NY: Doubleday, 1970), pp. 172, 164.

[19]Freeman, Mighty Eighth War Manual, pp. 98-100; Streetly, Confound and Destroy. pp. 80-92.

control radars almost useless, especially when jammers and chaff were used together. The commander of the Luftwaffe Flak school, Generalmajor Veith, said "..... as a result of active (electronics) jamming, radar at times became useless, and in such cases, Flak did not go into action at all."[20] If it did go into action under these conditions it was forced to use barrage fire rather than aimed fire, which vastly increased the amount of ammunition expended and greatly reduced the chances of hitting the bombers. The Flak batteries at the vital Romanian oil refineries at Ploesti, for example, calculated that they had to fire about 25,000 rounds to bring down one bomber under these conditions, compared to the 350 rounds required by American and British AAA batteries to shoot down one V-1 "Buzz Bomb".[21]

The effectiveness of ECM in degrading German defenses and holding down losses was also apparent to American airmen. In 1944 an internal Air Force memo on "RCM Planning for Combat Theaters" stated that "....it has become obvious that countermeasures are as effective and necessary as machine guns on the bombers."[22] By early 1944 the 8AF was asking for ECM equipment to be shipped to England "By the fastest available vessel as soon as production will permit."[23] As the aircrews saw for themselves what ECM did to cut losses and damage to Flak their appreciation for ECM rose accordingly. Not surprisingly, however, as new

[20]NDRC Div 15, "War in the Ether", p. 50; Price, History of US EW, Vol I, p. 194

[21]NDRC Div 15, "War in the Ether", p. 49.

[22]Quoted in Thompson, Signal Corps: The Outcome, p. 309.

[23]Ibid., p. 312.

crewmembers who had not experienced German Flak in the pre-ECM era came to the 8th Air Force, the task of "selling" ECM had to be done all over again.[24] The key was to convince the senior officers and commanders and to institutionalize their support by establishing policy and doctrine to insure that the "lessons learned" would not be forgotten.

Statistics provided a quantitative assessment of how effective ECM had been. Numerous German sources indicated that ECM had reduced Flak effectiveness by about three-fourths. During the last eight months of the war the 8AF flew about 30,000 bomber sorties under blind or radar bombing conditions, which meant that the German defenses were also totally reliant on radar for AAA control. The 8AF lost approximately 150 bombers to Flak during this time, about one-half of one percent of the total sorties dispatched. If the German Flak had been able to engage the bombers unhindered by ECM, statistics indicate that another 450 bombers would probably have been lost, along with their 4500 crewmembers. Another 200 or so bombers would have been lost by the 15th Air Force flying out of Italy. Expressed in this manner, the significant contribution made by ECM to Allied victory becomes more readily apparent, and a postwar study on "Intelligence Information on RCM Effectiveness in the European Theater of Operations" stated "It can be concluded with certainty that RCM had a marked success in protecting heavy bombers."[25]

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[24]Price, History of US EW, Vol I, p.188.

[25]NDRC Div 15, "War in the Ether", p. 78; 8AF "Flak RCM in the ETO", pp. 27-30, both in AOC Archives.

ECM in Combat: the Pacific

One of the most one-sided battles of the war against Japan was that between Japanese radar and American countermeasures: Japanese radar technology was far behind the Allies at the start of the war, and by the end it had fallen back even farther. The biggest boon to Japanese radar development was the capture of some American and British sets at Corregidor and Singapore in 1942. Despite the fact that these sets would soon be far from state-of-the-art equipment, the Japanese spent much of their radar effort in copying them. Their effort was further weakened by organizational failures and attitudinal problems. The endemic distrust and lack of cooperation between the Japanese army and navy led to separate research efforts and a failure to share results, while the rigid subordination of civilian scientists to military channels stifled creativity. The difference between the Japanese approach and the informal but highly effective cooperation and coordination shown by the American and British EW programs was a critical difference between Japanese failure and defeat and Allied success and victory.[26]

Japanese radars were primarily early warning, searchlight control, and AAA gun-laying. Possibly their greatest technical weakness was the narrow bandwidth of the frequencies they used, which meant that American ECM efforts could concentrate on those bandwidths and more easily overwhelm the Japanese radars. The primary

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[26]Price, History of US EW, Vol I, pp. 192, 226, 234; Guerlac, Radar in WWII, pp. 918-921; Lt. Otto Pflanze, 20th Air Force, 18th Historical Unit, monograph "RCM Reconnaissance and Countermeasures, 24 November 1944 - 1 June 1945", (hereafter cited as Pflanze, "RCM 1944-45") p. 20, 760.041-2, in AFHRA .

threat came from the searchlight and gun-laying radars in the Tachi series, which would be employed against the B-29 bombers of the XXI Bomber Command operating out of Guam, Saipan and Tinian in the Marianas Islands. The Japanese did have an early warning radar net, which functioned satisfactorily, and there was a small night fighter program which used a Tachi 20 GCI radar and an Irving fighter equipped with an early air intercept radar (AIR), but they played almost no role in the strategic bombing campaign against the home islands in 1945. The primary target for American EW would be the Japanese searchlight control and gun- laying radar (SLC & GLR) combination.[27]

Before the XXI Bomber Command's B-29s began operating out of the Marianas in early 1945 most Air Force EW activities in the Pacific had concentrated on ELINT gathering by Ferrets, although some early efforts had been made in locating, attacking and destroying Japanese radar sites.[28] The B-29 "Superfortress" had a tremendous advantage over earlier aircraft in that it was delivered from the factory with the space and electrical cabling necessary to support the installation of ECM equipment. This did not mean that the B-29 was an ideal platform for ECM: far from it, as reports sent back from the field indicated. The ECM equipment was awkwardly placed and impossible to repair in flight. Since the RCM observer was

[27]Price, History of US EW, Vol I, p. 226; Guerlac, Radar in WWII, pp. 919-920.

[28]Lincoln R. Thiesmeyer and John E. Burchard, Combat Scientists, a volume of the series "Science in World War II: History of the Office of Scientific Research and Development [OSRD]", Boston, Little, Brown & Co., 1947, p. 273; the story of "radar-busting" will be told in more detail later in this study.

not a regular crewmember he had to take whatever space was available, which happened to be on the chemical toilet seat! This position lacked basic equipment such as a safety belt or oxygen supply. Since most B-29s did not carry an RCM observer, however, this situation was confined to only those few aircraft that carried the extra crewmember required to perform spot jamming. Most countermeasures activities would be accomplished by the B-29s' radio operators, who were responsible for turning on the barrage jammers and dropping the chaff.[29]

The XXI Bomber Command (XXI BC) did not have a permanently assigned ECM staff officer until the arrival of Major Mel Jackson in March 1945. The XXI BC eventually comprised five bomb wings, each of which had four bomb groups with four squadrons each. Each wing, group and squadron was authorized one RCM officer (MOS, 7888), which meant that XXI BC was authorized eighty RCM officers. During the early months of 1945, however, the overall shortage of radar officers and the high level of training of the RCM officers resulted in many of them being assigned radar duties. By mid-April, for example, over one-fifth of the 7888s in XXI BC (which was seriously short of 7888s to begin with) were involved in radar operations, and it took the direct intervention of the XXI BC commander, General Curtis E. LeMay, to force the wings to return them to countermeasures duty. And

[29]Price, History of US EW, Vol I, pp. 151-160; NDRC Div 15 sent an observer to 20AF, Dr. Joe Pettit, whose papers and reports are on file in the AOC Archives.

just in time, for the big bombers were about to begin using ECM in earnest.[30]

In March 1945 the XXI BC initiated a series of operations unprecedented both for their destructiveness and for the tactical doctrine employed by the B-29s. General LeMay's switch from daylight high altitude precision bombardment to nighttime low-level incendiary attacks was a decisive change which placed greatly increased importance on the bombers' ECM capability. Before the night raids started there was little evidence that Japanese radar-guided AAA was widespread, but by mid-April it was certain that the searchlights were being guided by radar. During the 14 April raid on Tokyo, for example, there were numerous reports from returning crews of searchlights illuminating the bombers from the moment they were turned on, a sure sign of radar control. During the day the B-29s had usually bombed from altitudes in excess of 30,000 feet, but at night they often struck from less than 10,000 feet, greatly increasing the threat from radar controlled systems. This was painfully demonstrated during a daylight raid on 7 April 1945 against aircraft plants in Tokyo and Nagoya, in which the bombers carried 227 APT-1 barrage jammers and thousands of units of rope chaff. Bombing from altitudes ranging from 11,000 to 25,000 feet, well over 50% of the entire strike force suffered AAA damage. The high damage rates were less the result of poor or ineffective ECM, however, than a demonstration that operating at low altitudes and under conditions of unlimited

[30]Pflanze, "RCM 1944-45", p. 8; Steve Birdsall, Saga of the Superfortress: the Dramatic Story of the B-29 and the Twentieth Air Force, (New York, NY: Doubleday, 1980), pp. 324-325.

visibility was dangerous.[31]

For the next several weeks the ECM efforts of the XXI BC were primarily experimental, trying to develop a sound tactical doctrine. The use of RR-3/U rope increased as both the supply and the crews' confidence grew. In mid-April reports from crews using rope over Tokyo indicated that searchlights would concentrate on areas where large amounts of rope had been dropped. As soon as one or more lights "coned" a bomber the radio operator would rapidly dispense his supply of RR-3/U rope, which usually caused the lights to drift off the bomber when the radar broke track. Convinced of its effectiveness, General LeMay authorized the full-time use of rope at night or under conditions of poor visibility. The only drawback was that it was in such short supply. The crews thought highly of it: if they returned from a mission with unused rope they often took it to their tents, so they would have some for the next mission![32] During missions the crews' confidence in rope's ability to divert the dreaded searchlights was unbounded. Witness the experience of one radio operator/rope dispenser:

> "Since we were surrounded by lights, and the supply of rope limited, I would invariably run out of rope before the commands to drop it ceased. I never let on, however....the crew always praised me for getting the rope out in time. By the end of each overland flight I had

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[31]Pflanze, "RCM 1944-45", pp. 22-24; Birdsall, Saga of the Superfortress, p. 217; Price, History of US EW, Vol I, 227.

[32]Pflanze, "RCM 1944-45", p. 32; Price, History of US EW, Vol I, p. 229.

used more prayer than rope." [33]

By early May the attempt to develop a tactical doctrine for ECM had expanded to include active jamming. Aerial mining operations over Tokyo Bay, always a dangerous task, successfully employed barrage jamming to screen the B-29s from AAA and searchlights. On the 23 and 26 May missions to Tokyo, crews reported that the Japanese searchlights and AAA had exhibited an even greater degree of discipline and accuracy. On 26 May, therefore, the B-29s were granted unrestricted authorization to use electronic jamming against AAA and searchlight radars, although jamming of early warning radars and voice communications links for Japanese fighter control was prohibited, in part to preserve a useful source for intelligence. Shortages of ECM equipment and supplies such as jammers and chaff had limited the ability to fully employ EW against the Japanese, but by the end of May these problems had been sufficiently solved to enable increased use of this new weapon. The XXI BC was about to embark on a full-fledged ECM battle against the Japanese.[34]

The XXI BC had, after much trial and error, developed tactical doctrines for both the daytime and nighttime use of ECM. During the day the B-29s were instructed to fly in squadron formation, each of which was considered to be

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[33]Clayton L. Akin, personal letter to author, 14 October 1988.

[34]Pflanze, "RCM 1944-45", pp. 33-36; Memo, RCM Officer (Major Mel Jackson) to Communications Officer, 20AF, 12 September 1945, subj: "Some RCM Activities Between 29 May 1945 and 15 August 1945" (hereafter cited as Jackson "RCM Memo"), 760.907-1, both in AFHRA .

electronically self-sufficient. Most of the aircraft carried one APT-1 jammer pre-set to barrage jam the 185-205 MHz frequency bandwidth, which was the primary range of the Japanese AAA GLRs. These jammers were operated by the plane's radio operator. Another plane carried two APQ-2 spot jammers, usually operated by the squadron or group RCM officer, or by an extra radio operator or gunner. They also carried rope, which meant that each squadron could employ rope, spot and barrage jamming. The goal of XXI BC was to modify half of the B-29s to carry spot jammers, but the war ended before any unit attained this level. Although the jammers' success was less visible than a wildly inaccurate searchlight, the RCM officers who monitored Japanese radar transmissions noted case after case when the gun-laying radars shut down when the jammers came on the air. This translated into a decline in the rate of flak damage from 60% to 10%.[35]

Nighttime operations presented a totally different problem to the ECM planner: not only did he have to knock off the searchlight control radars in addition to those directing the AAA, but the impossibility of flying in a self-sufficient formation at night meant that some other way would have to be devised to screen the bomber stream as it passed over the target. The solution was an ECM escort, which came to be known as a "Guardian Angel" or "Porcupine", so-called because it literally bristled with antennas. Each squadron was to equip one B-29 with extra jammers and search equipment. In addition to the normal search receiver and three jamming

[35]Jackson, "RCM Memo"; Price, History of US EW, Vol I, pp. 227-229; Smith, "History of EW", p. 7; 313th Bomb Wing History, August 1945, both in AFHRA

transmitters carried aboard the "lead" ECM aircraft of each squadron, the Porcupines carried ten to fifteen more pre-set barrage jammers in the bomb bay.[36] Lt. Harry Smith, one of the cadre of ECM officers, described how they operated:

> "Normally the Guardian Angels would precede the main force of bombers to the target area, then begin jamming and fly racetrack patterns over the target at altitudes above about 12,000 feet. The lowest Guardian Angel would orbit clockwise, the next one up anti-clockwise, and so on up the stack. Since we arrived in the target area first, the gunners on the ground would start off by trying to engage us. That part of the mission could be very exciting. Soon afterwards the main force of bombers would start to come in at lower altitudes and they took the heat off us....As soon as the Guardian Angel B-29s started operating there was a dramatic reduction in the number of aircraft lost or which returned with damage. Overnight, the status of the RCM officer rose from "mere passenger" to "fantastic guy."[37]

The mission to Kure on 1 July was the first operational use of the Guardian Angel B-29s. That night four of them flew racetrack orbits over the target for 90 minutes: none of the bombers suffered flak damage. This success was repeated on other missions. It was obvious that the combination of rope and widespread barrage jamming by the bombers, and the ability of the Guardian Angel ECM escorts to spot jam whatever gaps occured in the jamming coverage, had a severe impact on the

[36]313th Bomb Wing History, August 1945; Jackson, "RCM Memo".

[37]Transcript of interview with Harry F. Smith (Colonel, USAF, Ret) in AOC Archives.

Japanese radar system.[38]

How effective was ECM in the bombardment campaign against Japan? Statistics indicate that it was extremely effective in holding down losses. Of the 214 B-29s lost due to all causes (and many of these were operational losses due to crashes, etc) only 28 were lost after the first of June, when the ECM war really got going. This was a loss rate of 1/3rd of 1 percent. A postwar report on "American Radar Countermeasures vs Japanese Flak and Early Warning Radar" prepared by the Air Technical Intelligence Group estimated that 200 American bombers were saved through the ECM program. Japanese sources confirm the effectiveness of the ECM program. One Japanese AAA officer who served in the Tokyo area throughout the B-29 campaign was interviewed by the United States Strategic Bombing Survey about the effectiveness of the bombers' countermeasures. He stated that jamming had impaired the efficiency of the radar system by about 90%. A precise determination of how many aircraft were saved by ECM is obviously impossible. It is apparent, however, that the net result of the countermeasures program was men and aircraft saved and more bombs on target.[39]

The overall success of the ECM effort, however, does not mean that problems or weaknesses did not exist. One that ECM shared with nearly everything else in the

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[38]Birdsall, Saga of the Superfortress, pp. 262-263; 313th Bomb Wing History, August 1945.

[39]Price, History of US EW, Vol I, p. 233; The Air Technical Intelligence Group's report is on file in the AOC Archives; United States Strategic Bombing Survey (USSBS), Interrogation Report #282, 1st Lt. Sekiguchi, 137.73-9 in AFHRA.

Pacific was a shortage of equipment. Not until late in the war did the bombers have an adequate supply of rope, and the supply of new and improved jammers was slow. Only 194 sets of the ARQ-8 "Dinamate", for example, which had twice the power output of the APT- 1, had been received by the end of the war. 20AF had designed an automatic rope dispenser, but by the end of the war only 22 installation kits had been delivered. Coordination between the unit RCM officer (who was assigned to the Operations staff) and the supply and maintenance staff was not always efficient. One wing solved this by adding an RCM officer to the supply and maintenance staff, even though such a position was not authorized by unit tables of organization. Regrettably, this ad hoc arrangement was not formalized and did not survive the war.[40]

Personnel deficiencies were another area which experienced difficulties. The most important positive, albeit belated, action was the arrival of Major Jackson at XXI BC headquarters in March, 1945. This placed an aggressive and experienced RCM officer at the headquarters and thus provided a guiding hand to the entire EW effort. One problem on which he acted was the supply of RCM officers, who arrived by way of the 2nd Air Force training program, where they had been pressed into service as radar officers. They thus arrived in the Pacific unprepared to serve as RCM specialists. This problem was corrected, although not before the end of combat operations, after Major Jackson intervened with his recent coworkers on the

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[40]Jackson, "RCM Memo"; Price, History of US EW, Vol I, p. 272; 313th Bomb Wing History, August 1945.

Air Staff![41]

Analysis of ELINT data also proved to be a problem. The B-29s gathered a great deal of intelligence data, but an emphasis on communications intercepts analysis meant that much ELINT data was never processed. This was part and parcel of a larger overall problem, the seemingly endless struggle over VHF communications jamming. The problem was that if the bombers jamm Japanese VHF communications between fighters and ground control stations, the intelligence intercept groups which listened to those very same communications would have their source cut off. Here, as in most cases, the intelligence agencies prevailed, to the dismay of the jammers. In this situation, as perhaps in all, that may have been the correct decision, but the day might come when the ability to jam the fighter control links would represent the difference between success and failure.[42]

Postwar

With the end of hostilities both the British and American EW communities tried to assess the effectiveness of their work. In Europe a branch of the Radio Research Lab, the "American-British Lab 15", prepared a report on the effectiveness of RCM. The investigators interrogated many German officers and did thorough technical examinations of captured equipment, in many cases shipping it to Eglin for field testing. In the Pacific, the Air Technical Intelligence Group undertook a similar

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[41]Jackson, "RCM Memo".

[42]Ibid.

effort. These were good, detailed reports, but they emphasized the technical aspects of the equipment and did not concentrate on American EW strategy and tactics: in short, they failed to look at the doctrinal side of the EW effort. Worse, when the RAF undertook just such an effort, the Air Force failed to take advantage of it. In late June and early July 1945 the RAF mounted an exercise called POSTMORTEM, which availed itself of the nearly complete German air defense net in Denmark. Despite some built-in artificialities (the RAF prohibited the Germans from actually flying intercepts, even with disarmed aircraft, because the British feared the Germans would head for Sweden!) the results of POSTMORTEM were the best available opportunity to safely test out the doctrine and make refinements while the test was in progress. Although the staff at Supreme Headquarters Allied Expeditionary Forces (SHAEF) received copies of the reposts on POSTMORTEM there is no indication that they were acted on or even reviewed. It is illuminating that the Air Force virtually ignored the doctrinal and procedural lessons from Europe even while shipping boatloads of equipment and technology back to the United States for testing and evaluation. Perhaps this resulted from a conscious decision to emphasize technical intelligence that might be applicable against the Japanese, or perhaps it was affected by the impending redeployment of combat forces to the Pacific. Whatever the cause, it was a significant failure on the part of Air Force leadership to not establish a mechanism for learning the EW lessons of the war.[43]

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[43]Price, History of US EW, Vol I, 192-194; Streetly, Confound and Destroy, pp. 113-131; Supreme Headquarters Allied Expeditionary Force, "Report of RAF Exercise

In November 1945 the Joint Board on Scientific Information Policy published a 38 page report on "Electronics Warfare: a Report on Radar Countermeasures". Given the extremely high level of wartime secrecy placed on countermeasures, it was a remarkably detailed explanation for the general public of what RCM was and the role it had played in the war. As a summary of accomplishments it was well done, but it was not a compilation of "lessons learned", a rigorous examination of why the various successes and failures took place and how future efforts could benefit from them.[44]

There were several reasons why such a report never was written. One obvious reason was the postwar demobilization program, which was rapid, massive, and chaotic. The chief of the Ferret training center at March Field reported that within a matter of weeks of VJ Day all of his instructors and students were gone.[45] A member of the RRL stated that "With the end of the war there was a great exodus of people from RRL. It was clear that the facility would soon close, and people were scrambling to snap up the good jobs outside."[46] This had a direct impact on the ability of those left behind who might want to write a postwar assessment of EW, because they were simply too busy trying to keep track what was happening day to

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POSTMORTEM", undated, 505.89-26, in AFHRA.

[44]Joint Board on Scientific Information Policy, Electronics Warfare: a Report on Radio Countermeasures, (Washington, DC: GPO, 1945.)

[45]Manbeck letter to author, 31 March 1989

[46]Joseph Kearney, quoted in Price, History of US EW, Vol I, p. 248.

day. The Air Staff ECM section had been reduced to just two officers, for example, and the situation at other headquarters was as bad if not worse.[47] The failure to compile such a study was one of the more significant shortcomings of the Electronic Warfare program.

Even if such a study had been prepared, the almost total lack of an institutional mechanism for turning lessons into doctrine, or for translating needs into formal R&D requirements for new equipment and capabilities, made it difficult to act on those lessons quickly and efficiently. No matter how far-sighted an operational concept might be, or how technologically advanced a new piece of equipment, unless they become institutionalized via doctrine they will never see a day of combat. A later chapter will examine Air Force doctrine in more detail; suffice it say for now that the end of the war saw no method or agency in existence that could take the electronic lessons of the war and transform them into plans or equipment.[48]

An additional shortcoming concerned the knowledge level about EW among the current and future Air Force leaders. Luftwaffe General Josef Kammhuber, who had developed the German air defense system, commented on the need to educate the senior leadership: "....a high level officer can no longer afford to regard electronic

[47]Winter letter to author, 15 March 1989.

[48]Manbeck and Winter agree that they know of no such "after action report" or "lessons learned" type of study. Two large studies were prepared after the war, "Summary Technical Report of Division 15, NDRC, Volume I, Radio Countermeasures", and the "Administrative History of the Radio Research Laboratory", but these reports were not of such a nature that they could be used by postwar planners to plan for the follow-on R&D and employment of ECM.

warfare as the specialized field of a few experts....every commander in a responsible position should be oriented regarding its basic features and be fully familiar with its essential principles."[49] The old military maxim that a war's losers sometimes learn more than the winners may be applicable in this case, for the Air Force did a poor job of "spreading the word" about EW. The senior officers of XXI BC, many of whom rose to high positions later in the Strategic Air Command, seemed aware of EW's contribution, but this was because they were involved in daily combat operations with it. For whatever reason, they were not able to insure that this important new weapon was effectively incorporated, doctrinally, into the peacetime Air Force. As a result, the rest of the Air Force was generally unfamiliar with electronic warfare; later, many of the electronic lessons learned during the war would have to be relearned.

Ironically, the seeds of the last shortcoming lay in the great success EW had in the war. Participants frequently cited the close and effective integration of the scientific, technical and military elements as the primary factor in the tremendous advances made during the war. The lack of rigid organizational channels, freedom of action granted to junior officers, the sense of urgency, and extremely close cooperation meant that the Air Force's EW program far surpassed that of the Germans and Japanese.[50] The problem was that this close cooperation and

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[49]Winter letter to author, 15 March 1989.

[50]Ibid.; Manbeck letter to author, 31 March 1989.

coordination resulted from the fact that the nascent EW community was so small everyone knew everyone else. Many of the young specialists at RRL, for example, were former students of the senior staff. The same held true for the small cadre of ECM officers in the Air Force, who were junior in rank and regarded primarily as technical specialists. What resulted was an informal network of EW specialists doing superb work within an ad hoc organization under the pressure of a wartime emergency. When the war ended and the sense of urgency dissipated, the ad hoc organizational structure also terminated, resulting in the rapid scattering of the informal network. The failure to develop a formal mechanism by which continued R&D in electronics could be pursued meant that any sort of follow-on EW program would be hamstrung for a long time, and that time, money, aircraft and possibly lives would be wasted.

CHAPTER THREE

SCHIZOPHRENIA: DEMOBILIZING WHILE BUILDING AN AIR FORCE, 1945-47

The months following the end of the war saw the Air Force attempting to accomplish the seemingly contradictory goals of rapid demobilization, gaining autonomy as a separate service, and building a strong new Air Force. The effects of demobilization were nothing short of disastrous, and within a year the giant wartime organization was literally gutted of men, aircraft and resources. At the same time, the preoccupation of the air leaders with gaining independence from the Army and establishing a separate service had a negative impact on improving its combat capability. Finally, the air arm was trying to find a philosophy and focus for future research and development. Perhaps inevitably, the Electronic Warfare program suffered.

Air Force Autonomy

The first twenty-odd months after the end of the war saw senior air leaders engaged in two critical tasks. One resulted from the national mandate to demobilize and return the millions of citizen-soldiers to their peacetime pursuits. The other originated in the fierce desire of American airmen to attain independence as a separate service. There is no need to retell here the story of how the "Army Air Force" became the "United States Air Force" in 1947, but what is sometimes overlooked is the impact that effort had on overall combat capability. It is, of course, impossible to quantify how much collective attention and effort in 1946-47 went into the struggle for autonomy, but certainly it was enormous.[1]

The case of General George Kenney is illustrative. General Kenney, a colorful war hero and the first commander of the Strategic Air Command, spent much of his time speaking to groups across the country about the potential of airpower and the need for Air Force independence. He spent so much time doing this, in fact, that his second in command at SAC, Major General Clements McMullen, exercised de facto command. General McMullen, however, had no operational experience with bombers, and he set about implementing his own ideas on how the command should be organized. Although this will be covered in more detail in a later chapter, SAC's operations during this period focused on numbers and showmanship, such as a massed formation flight of bombers over New York City. Such operations garnered newsreel footage and may have helped convince Congress that Air Force independence was in the nation's best interests, but they did nothing to improve combat capability.[2]

Not surprisingly, the EW program suffered while Air Force leaders focused their attention on the battle for autonomy. One of the chief civilian scientists involved in

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[1]Thomas A. Sturm, The USAF Scientific Advisory Board: Its First Twenty Years, 1944-1964 (Washington, DC: USAF Historical Division, 1967), p. 22; Donald E. Wilson, "The History of President Truman's Air Policy Commission and its Influence on Air Policy, 1947-1949", (unpublished PhD Dissertation, University of Denver History Department, Denver, CO; hereafter cited "Air Policy Commission", 1978), p. 25.

[2]Harry R. Borowski, A Hollow Threat: Strategic Airpower and Containment Before Korea, (Lockport, CN: Greenwood Press, 1982), pp. 27, 140-41; Harry R. Borowski, "Air Force Atomic Capability from V-J Day to the Berlin Blockade--Potential or Real?", Military Affairs, 44 (October 1980), pp. 105-110.

EW at the time summed up the general attitude as "Forget about countermeasures--it was a wartime weapon and there's no need for it in peacetime."[3] The problem was that EW was regarded as a technical speciality, an attitude almost certainly influenced by its Signal Corps origins. Being regarded as a technical speciality brought it squarely up against attitudes like that of General McMullen at SAC, who once remarked that SAC had "no need for Quartermaster colonels", meaning that unless an officer was a flyer he was not needed.[4]

Demobilization

The EW program would have fared better during this period if demobilization had not been underway, but the mass confusion and turmoil which followed the end of the war made this almost impossible. Following the national precedent of trying to make the change from all-out wartime effort to peacetime "business as usual" as quickly as possible (the aftermath of the Civil War and World War I were two prior examples), within twenty-four hours of Japan's surrender contract termination notices were sent to over 3000 contractors, terminating over 10,500 contracts worth over $8.5 billion. Within a month 95% of the War Department's contracts had been terminated, and by the end of November the total stood at 300,000 contracts worth

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[3]Transcript of Interview, Dr. George Rapoport, on file at the Association of Old Crows (AOC) Archives, Alexandria, VA.

[4]Borowski, A Hollow Threat, p. 141.

$64 billion.[5]

This massive wave of contract terminations had several negative results for the aerospace industry as a whole and for the EW program in particular. The aircraft industry workforce declined from over 1,270,000 workers in May 1944 to 158,000 in January 1947, crippling some of the wartime giants. In the more specialized field of EW, most of the major wartime contractors such as Zenith and RCA lost interest in the vanishing military electronics market. Only a few companies, such as Raytheon and Hallicrafters, remained actively interested in military projects. The Radio Research Lab (RRL) budget showed even more dramatically the impact of demobilization, dropping from a wartime high of $12,200,000 in fiscal year 1944 to $113,000 two years later, and its work was literally yanked to a halt. On 23 August 1945 it was directed to prioritize all ongoing work into one of three catagories; those projects which could be terminated immediately; those projects which could be terminated after they reached a point where useable records or equipment could be preserved; and those projects which could be continued at another Air Force, Army Ground Force, or Navy facility. All work was to be completed by the 1st of November.[6]

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[5]Wilson, "Air Policy Commission", p. 33; Jack S. Ballard, <u>The Shock of Peace: Military and Economic Demobilization After World War II</u>, (Washington, DC: University Press of America, 1983), p. 135.

[6]Wilson, "Air Policy Commission", p. 33; Ballard, <u>The Shock of Peace</u>, p. 140; Walter H. Wager, "The Air Coordinating Committee", <u>Air University Quarterly Review</u>, II, #4 (Spring, 1949), p. 21; Rapoport Transcript, AOC Archives; Irvin Stewart, <u>Organizing Scientific Research for War: the Administrative History of the Office of</u>

One obvious result of the thousands of contract terminations was that the flow of airplanes to the Air Force stopped dead in its tracks. During the four years of the war, for example, the Air Force accepted over 95,000 bombers, but the next two years saw only 449 bombers delivered to the Air Force, and most of those were medium or tactical aircraft. Thousands of aircraft had been scrapped or mothballed in storage. At the end of 1946 only the 509th Bomb Group, based at Roswell Field, New Mexico, was capable of dropping the Atomic Bomb, and only 27 of its B-29s were modified to carry the weapon. By mid 1947 SAC had no more than 160 B-29s that were actually operational. It had eleven bomb groups organized on paper, but only the 509th and 43rd Bomb Groups were considered combat effective: the rest were capable only of limited operations and only for brief periods of time. As Harry Borowski noted in his book Hollow Threat, by 1948 SAC was hardly the combat-ready force it was widely understood to be.[7]

If people are the real muscle behind a military force, then the Air Force by mid-1947 had undergone a near cancer-like atrophy. From a wartime high on VE Day of 2,300,000 men, the Air Force had shriveled to just over 305,000 two years later. The pressure from both Congress and the American public to demobilize

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Scientific Research and Development, (Boston, MA: Little, Brown & Co., 1948), p. 93; Air Communications Office Daily Diary, 24 August 1945, 123.401, in AFHRA.

[7]Borowski, A Hollow Threat, pp. 91, 103; Wilson, "Air Policy Commission", p. 300; Borowski, "Air Force Atomic Capability from V-J Day to the Berlin Blockade--Potential or Real?", pp. 105-110; Kenneth W. Condit, The History of the Joint Chiefs of Staff: the JCS and National Policy, Volume II, 1947- 49, (Washington, DC: Historical Division, Joint Secretariat, JCS, GPO, 1978), pp. 18-19.

quickly was intense: General Eisenhower described it as reaching "proportions of near-hysteria", and slogans such as "Bring Back my Daddy" and "No boats, no votes" aptly described popular feelings and pressures. Air Force demobilization quickly got underway, and just as quickly ran out of control. Not until early 1946, by which time over 700,000 men had already been returned to civilian life, did the Air Force begin to get reliable statistics and accurate personnel records, according to General Carl Spaatz, the first Chief of Staff of the new USAF. Personnel records were inaccurate and untrustworthy: at times the Air Force did not even know how many men were on active service; at some locations daily musters were held merely to get an accurate head count of how many men were on hand! By early 1947, when President Harry S. Truman announced his determination to "Support free peoples everywhere", the US had been so weakened militarily that George C. Marshall felt "... [we were] playing with fire while we have nothing with which to put it out."[8]

All the armed forces lost vast numbers of trained and experienced men, but the Air Force was perhaps hardest hit, because of its total reliance on complex equipment and advanced technology for combat effectiveness. A little over a year after the end of the war the number of combat-effective groups had declined from 218 to just 2, and the number of aircrew personnel from 413,000 to 31,600. Six

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[8]Report of the Chief of Staff USAF to the Secretary of the Air Force for 1948, (hereafter cited CSAF Report), pp. 7-8; Ballard, The Shock of Peace, pp. 88-89; Condit, History of the JCS, pp. 18, 553.

months later that number dropped to 24,000. By the end of 1946 nearly 85% of the wartime personnel had been demobilized, with catastrophic results to the various training programs. Training programs for new pilots and other aircrew personnel were virtually non-existent, and severe shortages appeared in many critical specialities.[9]

Not surprisingly, the EW and ECM field was hit hard, as men left the military and took their valuable skills to the growing electronics industry. By March 1946 the Air Force was short nearly 4000 communications officers out of a total authorization of 5600.[10] The lure of civilian jobs was not the only factor, however, in the rapid decline of the Air Force's EW capability: attitudinal factors perhaps played an even greater role. General Don Putt, a major figure in developing the Air Force's R&D capability during its first decade, remarked that there used to be an attitude within the military summed up in the comment "those long-haired scientists, we can do without."[11]

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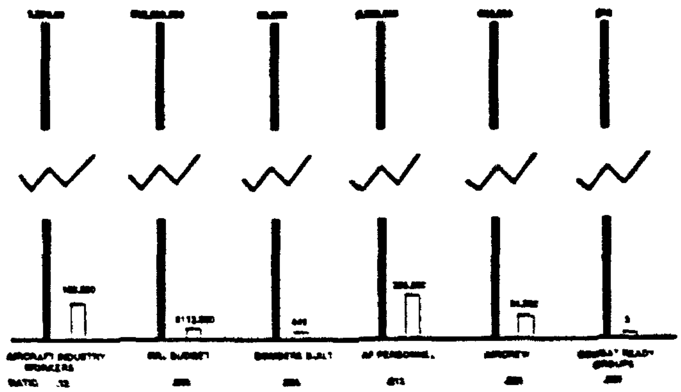
[9]CSAF Report, 1948, pp. 9, 13; Borowski, A Hollow Threat, p. 43.

[10]Mario de Arcangelis, Electronic Warfare: From the Battle of Tsushima to the Falklands and the Lebanon Conflicts, (Dorset, UK: Blandford, 1985), p. 108; Strategic Air Command Office of History, "Development of Strategic Air Command Electronic Countermeasures Program" (hereafter cited as "SAC ECM Program"), Volume V, Chapter 6 of SAC 1951 History, p. 19; ACO Daily Diary, 26 March 1946.

[11]Irving B. Holley, Jr., in Harry R. Borowski, ed., Military Planning in the Twentieth Century: Proceedings of the Eleventh Military History Symposium, 10-12 October 1984, (Washington, DC: Office of Air Force History (OAFH), GPO, 1986), p. 152, note 62; the quote is from an Air Force Oral History Program interview with General Don Putt.

Figure 4
DEMOBILIZATION: WARTIME HIGHS vs POSTWAR LOWS



Although the EW officers in the Air Force did not fall into the "long-haired" category, they were regarded by many as technical specialists who were unnecessary during peacetime, and the number of ECM officers was greatly reduced. Lt Harry Smith, for example, ended up in Florida teaching weather radar; another EW pioneer, Lt. Joe Wack, was advised by his squadron commander to retrain as a radar bombardier; and Captain Les Manbeck, who was the Chief of the ECM Branch at SAC (he had to be chief: he was the only officer in the branch!) in 1946, spent most of his time trying to find ECM officers to assign to bomber units.[12] By early 1947 the small but crucial pool of trained ECM officers had been scattered, and the EW program was in tatters.

Even if the Air Force had possessed sufficient numbers of aircraft and men, the equipment shortages which followed demobilization eliminated any real capability to

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[12]Transcripts of Interviews with Harry F. Smith (Colonel, USAF, Ret), and Joseph Wack, AOC Archives; Lester Manbeck, letter to author, 4 December 1988.

conduct EW operations. At most bomber bases the little ECM gear there was packed away in the supply warehouse. The ECM branch on the Air Staff had little to do other than disposing of surplus equipment, and most of the jamming equipment produced during the war was in fact sold on the surplus market. It is impossible to reconstruct a precise record of the Air Force's electronic demobilization, because of the fragmentary nature of the data, but some raw numbers indicate its extent. In May 1946 the War Assets Administration (WAA), the overall manager for the services' equipment disposal programs, reported that the services had declared $557,000,000 of electronics equipment surplus, with another $1,600,000,000 to come! The situation was so confused that the Air Force listed thirty-four warehouses and depots which could not provide even approximate inventories of their surplus gear. That summer the Assistant Director of the WAA's Electronics Division angrily resigned his position, frustrated by the confusion, lack of people, and "uninformed direction" of the overall program. The quarterly reports of the WAA indicate that the Air Force disposed of nearly a billion dollars worth of surplus communications and electronics equipment by 1949. By no means was all of this combat-ready gear: much was junk. But there would be cases in the coming months of Air Force officers quietly going out in civilian clothes and buying back surplus ECM equipment in order to have even an interim EW capability.[13]

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[13]Hugh Winter, letter to author, 7 November 1988; Smith, "The History of Electronic Warfare", p. 18; House of Representatives, US Congress, Hearings Before the Select Committee to Investigate Disposition of Surplus Property. 79th Congress, 2nd Session, Hearings on House Resolution 385, "A Resolution Relating to Disposition of Surplus

By 1947 the Air Force had, as a result of demobilization, reached a point where it would have to start almost completely from scratch to rebuild its EW capability. As one of the few ECM officers active at the time said, "We had no equipment, no aircraft installations, no training programs, no training aids, no doctrine, no research and development programs to speak of and only a handful of RCM officers to begin anything with."[14] The fact that the services would demobilize after the war should have come as no surprise to anyone: witness the American experience after World War I.[15] But the pace and confusion of the World War II demobilization almost certainly caught most Air Force leaders by surprise. Officers who could and should

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Property" in two parts, 23-27, 30 September, 1-4 October 1946, pp. 1523-1529 (Exhibit 174), p. 1539 (Ex 183); War Assets Administration, Quarterly Progress Report to the Congress by the WAA; Transcript of interview with William Howe, AOC Archives; Ballard, The Shock of Peace, p. 158.

[14]Frank Lindberg, (Colonel, USAF, Ret.), letter to the author, 16 May 1989; "CSAF Report. 1948. pp. 16-17.

[15]The process of demobilization, however, has never been as well studied as mobilization. The Pentagon Library, for example, lists more than a hundred entires under the heading "Mobilization", only four under "Demobilization." See the standard work on the mobilization process, Marvin A. Kreidberg and Merton G. Henry, History of Military Mobilization in the United States Army, 1775-1945 for an accurate and in-depth assessment of the American mobilization process. For demobilization see Jack S. Ballard's book The Shock of Peace: Military and Economic Demobilization After World War II, or three doctoral dissertations: Theodore John Conway's "The Great Demobilization: Personnel Demobilization of the American Expeditionary Force in the Emergency Army, 1918-1919; a Study in Civil-Military Relations" (Duke University, 1986); Christiann Lea Gibson's "Patterns of Demobilization: the U.S. and USSR After World War II" (University of Denver, 1983); and Bert Marvin Sharp's " 'Bring the Boys Home': Demobilization of the United States Armed Forces After World War II" (Michigan State University, 1977). Air Force Historical Study #59 on "Demobilization Planning for the United States Air Force" by Chauncey E. Saunders (and an earlier version, Historical Study # 77 on "Redeployment and Demobilization") provide details on Air Force activities.

have prepared useful "after action" reports or summaries of lessons learned found themselves either being demobilized or trying to hold together an office or function while the Air Force around them seemed to dissolve; one Air Force history described this period as marked by "utter confusion, pervading all echelons of command".[16] By late 1947 the Air Force had lost most of the people, aircraft and equipment needed to sustain combat operations. Fortunately, while this was happening the Air Force was also establishing the fundamentals of an R&D program that would be one of the first requirements for rebuilding its EW capability.

Research & Development

One of the clear lessons of the war was that the process of conducting scientific and technical research; designing, developing and testing new weapons; and procuring those weapons was an ongoing process which needed to be vigorously pursued in peacetime. Even before the war ended the Air Force set about determining how this could best be accomplished. Although the individual activities of various men and agencies was at times confusing, they provided a framework within which this process occurred, and they sounded a clear and persistent call for a strong Air Force. As the EW program got underway again, it would be affected by a variety of influences.

In early November 1944 General Hap Arnold, the commander of the Army Air

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[16]Chauncey E. Sanders, Air Force Historical Study #59, "Demobilization Planning for the United States Air Force", (Air Force Historical Division, Research Studies Institute, Air University, Maxwell AFB, AL: 1954), p. 46; 101-77 in AFHRA.

Forces, directed Dr. Theodore von Karman to assemble a group of experts and prepare a report on the "recommended future" of the Air Force's research and development programs. As von Karman remembered it, General Arnold wanted "to secure scientific insight in a standing Air Force...to secure the interest of the scientists of the nation to help the future Air Force..and to educate the people of the nation that for our security we must have a strong Air Force."[17] This was the genesis of the Air Force's Scientific Advisory Group, now called the Scientific Advisory Board (USAF/SAB). His formal letter to the SAG called for long range thinking to develop programs that could guide the shape of Air Force R&D for the next two decades and support congressional budget appropriations. This was a hefty assignment, but if it succeeded the Air Force would establish the conceptual framework for the R&D of future weapons systems.[18]

Within a year von Karman and the SAG produced two landmark studies, Where We Stand (22 August 1945) and Science: the Key to Air Supremacy (15 December 1945), although they were best known by their collective title, Toward New Horizons. Their central message was that the Air Force must conduct large-scale R&D during peacetime if it hoped to have superior weapons for any future war. Based on an in-depth survey of American and European technology, Where we Stand set forth several "fundamental realities" of future aerial warfare, of which two would

[17]Sturm, The USAF SAB, p. 5; Al Gropman in Borowski, ed., Military Planning in the Twentieth Century, p. 165.

[18]Ibid., p. 165;

be of particular interest to the Electronic Warfare program:

1) "Defense against present-day aircraft would be perfected by target-seeking missiles"
2) "Only aircraft or missiles moving at extreme speeds would be able to penetrate enemy territory protected by such defenses"[19]

Science: the Key to Air Supremacy, on the other hand, addressed itself more to the issue of how Air Force R&D would be structured within the Air Force organization. Regardless of where the Air Force R&D function was placed, however, von Karman clearly meant for the Air Force to play a major role in conducting basic research.[20]

Some of the findings of the SAG proved to be remarkably prescient, but it seemed to neglect the wartime role of EW. The two findings cited above are perfect examples of this. That target-seeking missiles would be perfected was entirely reasonable: the Germans had several under development when the war ended. But this finding ignored the probability that if a target-seeker could be developed so too could countermeasures to negate it, whether the seeker used infrared, radar, or optical guidance. By placing the emphasis on speed to obtain the ability to penetrate enemy defenses, the SAG helped to initiate an Air Force philosophy that produced a series of bombers (B-47, B-58, B-70) that relied on speed and altitude as their primary aid to penetrating enemy airspace and negating enemy air defenses. Radar

[19]Michael H, Gorn, Vulcan's Forge: the Making of an Air Force Command for Weapons Acquisition, 1950-1985, (Andrews AFB, MD: Air Force Systems Command Office of History, 1986), pp. 2-3.

[20]Ibid., pp. 3-4; Nick A. Komons, Science and the Air Force: a History of the Air Force Office of Scientific Research, (Arlington, VA: Office of Aerospace Research Historical Division, 1966), p. 5.

countermeasures were not totally ignored: Science: the Key to Air Supremacy noted that the "Vulnerability of a target-finding radar to jamming is no less important than the vulnerability to fighter attack of the vehicle which carries the radar and the bomb." It also pointed out several promising areas for future R&D.[21] One of the several study groups which comprised the SAG published a report in May 1946, "Radar and Communications", which included a brief chapter on radar countermeasures, but the report's focus was on radar and its future, not on countermeasures. As useful as Towards New Horizons might be in shaping future Air Force R&D, its impact on EW was negligible. Given General Arnold's advice that an Air Force must "keep its doctrines ahead of its equipment", the SAG missed the mark on the future of Electronic Warfare.[22]

If von Karman and the SAG set the tone for Air Force R&D, Vannevar Bush and the National Defense Research Committee (NDRC) did the same for the entire national military establishment throughout the war. Recall that the Radio Research Lab, which developed nearly all of the ECM devices used by the Air Force during the war, was part of NDRC Division 15. When Bush organized the NDRC in 1940 he successfully brought the American scientific and military establishments closer

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[21]USAF SAG, Science: the Key to Air Supremacy, in Record Group 341, section VIII/B, DCS/Development, Assistant for Development Programs, Box 163, NARS, Washington, DC.

[22]USAF SAG, "Radar and Communications", Wright Field, Ohio, Air Materiel Command, 1946, pp. 163-167; Gropman, in Military Planning in the Twentieth Century, p. 105.

together. A year later, when the NDRC became part of the newly-formed Office of Scientific Research and Development (OSRD), the bond was strengthened. Despite several operating practices which disturbed the military, (such as reporting directly to the president and thus avoiding military channels and/or bottlenecks), the close cooperation and coordination between the military and civilians was remarkable.[23] As Bush said later, "...most of the worthwhile programs of NDRC originated at the grass roots, in the sections where civilians who had specialized intensely met with military officers who knew the problem in the field."[24]

Bush published several books after the war which discussed the work of the NDRC and outlined his philosophy on R&D for national defense. His books Science: the Endless Frontier: A Report to the President on a Program for Postwar Scientific Research [published in 1945] and Endless Horizons [published a year later] set forth his concepts on how a military research organization should function. He believed that there "Must be adequate planning at the top both for the evolution of weapons and for the strategic use of new weapons" and that "The position of the technical man in uniform must be improved".[25] But Bush saw two fundamental problems with the military unilaterally doing its own R&D. The internal organization of the services, he felt, gave insufficient recognition to scientific

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[23]Alex Roland, "Science and War", Osiris, 11, 1985, pp. 263-64; Vannevar Bush, Pieces of the Action, (New York, NY: Morrow, 1970), p. 31.

[24]Ibid., p. 48.

[25]Bush, Endless Horizons, Washington, DC., Public Affairs Press, 1946, pp. 86-90.

requirements and potential. The other was the military psyche: military personnel did not appreciate either the position scientific research must occupy or how it would contribute to national defense.[26] As he wrote three years later, "Military men...can grasp the value of a device before them; they...by no means...can visualize intelligently the devices of the future."[27]

In developing his philosophy that military research should be done by civilians in an arrangement that not coincidentally paralled that of NDRC Division 15 during the war, Bush had unerringly placed his finger on several influences which would hamper the development of ECM. His views on the internal organization of the services was particularly appropriate to the Air Force. Not only was Electronic Warfare organizationally mired within the Air Communications Office, which made it more of an accessory than a combat weapon, but no individual agency seemed to have full control and authority over it.[28] Even more on the mark was his comment on personnel and the position of the technical man in uniform. Just when technology

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[26]Ibid., pp. 83-84.

[27]Bush, Modern Arms and Free Men: a Discussion of the Role of Science in Preserving Democracy, quoted in Gropman, Military Planning in the Twentieth Century, p. 157, footnote 5; see also Irving B. Holley, Jr., Ideas and Weapons, for a discussion of the relationship between doctrine and technology.

[28]The Combat Electronic Systems Branch was one of three branches within the Electronic Division, which itself was one of three divisions under the Director of Communications, itself one part of the Operations Deputate. There were also several other agencies which had an interest in EW, including the Proving Ground at Eglin, Air Materiel Command, and the Director of Requirements at HQ Air Force, to name just three that were primarily concerned with R&D. This does not even mention the combat commands such as SAC, the eventual users of the equipment.

was becoming increasingly important to aerial warfare, the Air Force was losing large numbers of electronics specialists, especially the small cadre of ECM officers. Worse, in some organizations, such as SAC under General McMullen, they were being pushed intentionally out in favor of pilots and rated officers. The situation reached the point where Congress became concerned over the high turnover in military research personnel. Organizational problems could be worked out, but the attitudinal ones such as this would prove to be harder to solve.[29]

Military R&D was also affected by other governmental boards and agencies, more indirectly perhaps, but in ways that had a greater impact on the organizational structure of the Air Force. In July 1947 President Truman appointed the Air Policy Commission (APC), headed by Thomas Finletter, and tasked them to study the current and future needs of American aviation, examining the nature and type of industries needed to advance aviation, what methods of management should be used, and what the best organization would be to accomplish that goal. The Air Policy Commission was clearly an ad hoc body and somewhat duplicated the existing Air Coordinating Committee (ACC), which was comprised of representatives of the Departments of State, War, Navy, and Commerce, as well as the Post Office and Civil Aeronautics Board. President Truman obviously hoped that the APC would not be subjected to the same sort of bureaucratic influences as the ACC faced.

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[29]Letters to the author from Lester Manbeck, 4 December 1988, and Hugh Winter, 7 November 1988; Borowski, A Hollow Threat, p. 141; Wilson, "Air Policy Commission", pp. 106-107.

Congress, not to be outdone, created its own study group, the Aviation Policy Board (or Brewster Board, after its chairman, Senator Owen Brewster of Maine) a few days after the creation of the APC. Hardly anything was being studied more intently than aviation during the summer of 1947 in Washington![30]

All came to the same general conclusion: America's defense rested on her strength in the air, and the nation needed an Air Force second to none, equipped with the finest aircraft that science could provide. The report of the APC, however, probably had the greatest impact. Entitled Survival in the Air Age and published in 1948, the Finletter Report (as it was also known) placed particular emphasis on the importance of research and development: "There is little need to stress the point that intense research and development in aeronautics are essential to the national defense and to the national welfare."[31] Finletter agreed with von Karman that the Air Force needed to be deeply involved in the R&D process, but also said that the Joint Research and Development Board, a civilian organization modeled along Vannevar Bush's concepts, should be the primary agency responsible for overseeing R&D. One item which Finletter highlighted as a problem area was the high turnover of military officers in research positions, and he recommended offering inducements to

[30]Thomas K. Finletter, chairman, Survival in the Air Age: a Report by the President's Air Policy Commission, (Washington, DC: GPO, 1948), pp. iii-v; Wager, "Air Coordinating Committee", pp. 20-23; National Aviation Policy: Report of the Congressional Aviation Policy Board, 80th Congress, 2nd Session, Senate Report #949, (Washington, DC: GPO, 1948), p. 1.

[31]Finletter, Survival in the Air Age, P. 73.

officers to go into aeronautical R&D, even sending them to graduate school at government expense. As previously noted, however, this ran headlong into the pro-operational bias epitomized by General McMullen at SAC or General Putt's observation on Air Force attitudes towards "those long-haired scientists".[32]

The Finletter report had its greatest impact on the organizational structure of the Air Force and its R&D process. Research and Development was assigned to the Air Materiel Command (AMC), headquartered at present-day Wright-Patterson Air Force Base, Dayton, Ohio, not far from where a pair of bicycle makers named Orville and Wilbur Wright grew up. Both the Finletter report and an internal Air Force study conducted in 1948 felt that AMC was too concerned with procurement, supply and maintenance to effectively manage the R&D function. It may have been organizationally elegant to have one agency control materiel from design through supply and repair but it was bureaucratically dysfunctional. The long-range needs of R&D fell victim to the short-range needs and day-to-day pressures of procurement and supply. In an era of tight budgets and very limited funds this was a logical and understandable situation: it was also unacceptable. The solution was also logical and understandable, although not implemented until 1950: the creation of a separate Air Force agency for research and development.[33]

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[32]Komons, Science and the Air Force, p. 8; Wilson, "Air Policy Commission", pp. 106-107; Gropman, Military Planning in the Twentieth Century, p. 152.

[33]Komons, Science and the Air Force, pp. 11-15; Gorn, Vulcan's Forge, pp. 6-7; Finletter, Survival in the Air Age, p. 73.

Where did all of this leave Electronic Warfare? Out in the cold, languishing for lack of support. With Air Force R&D being underfunded it was not surprising that work on EW progressed slowly and painfully. Although electronics had been identified as a key area in Survival in the Air Age EW was a minor and little-known piece of the pie. The ECM community characterized the existing program as "very small...very inadequate".[34] This was partly the result of confusion and uncertainty within the Air Force. In September 1945 the Air Communications Office sent to the Requirements Division its recommendations for postwar adjustments to the RCM program. The recommendations were based on three assumptions, two of which were straightforward: an aggressive electronic intelligence program would be needed, and RCM demonstrations and training would be conducted as routine parts of the services' training program. It also assumed that in the event of large-scale hostilities an RCM program would be required, but included the curious comment that "routine offensive RCM operations in bombardment aircraft" would not be required, thus effectively implying that no day-to-day need for RCM existed. The list of recommendations also failed to mention R&D.[35] In October 1947 the Aircraft Radio and Electronics Committee noted that although they "fully realized the importance of

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[34]Gorn, Vulcan's Forge, p. 6; Watson Labs, Minutes of the Watson Labs Countermeasures Group (hereafter referred to as "Watson Notes on Countermeasures"), 30 June 1947, p. 7; this was an ad hoc group of civilian scientists and military officers, most from Wright Field, who met periodically to compare work and interface with the Joint Research and Development Board; the AF Historical Research Agency has one year's set of minutes, for 1947, 215.91-102.

[35]ACO Daily Diary, 6 September 1945.

countermeasures, practical considerations... [meant] that countermeasures was a field for which adequate funds would become increasingly more difficult to obtain since operational priorities were higher in other electronic areas."[36] It seems safe to say that just as the overall Air Force in 1945-47 was in a constant state of flux, so too was the EW program.

An R&D Plan for EW

Despite the lack of activity in the R&D program for EW, however, the planning for such a program had fortunately made some limited but important strides. In September 1946 the Air Force and Air Material Command developed a policy to guide R&D in countermeasures equipment. The "Proposed Countermeasures Equipment Research and Development Plan" was probably developed by the Director of Requirements at the Air Staff and coordinated with the Aircraft Radiation Lab at Wright Field. It contained three sections: a general discussion of the EW situation; a series of general conclusions concerning basic guidance for the program; and a list of specific equipment requirements. The plan assumed that electronics would play an increasingly important role in aerial warfare, and it established an ambitious objective of providing the Air Force "with RCM equipment to render ineffective any electronic weapons employed against us." It noted that although anti-aircraft guns would continue to be a threat, they would eventually be supplanted by guided surface-to-air missiles (SAMs), and it established as basic planning considerations the need to

[36]"Watson Notes on Countermeasures", 10 November 1947, pp. 2-3.

develop countermeasures against our own electronic devices as well as RCM covering the entire elctromagnetic spectrum. It stated that the ELINT program was as important as offensive ECM and thus had its own particular equipment requirements. Finally, it noted that development of offensive ECM systems needed to include equipment to jam enemy guided SAMs, early warning radar systems, and comunication components of an enemy air defense network.[37] The plan went on to outline several general conclusions about the principles which the EW program should follow and the form it should take. In concert with the spirit expressed by both Vannevar Bush and Theodore von Karman, it recommended very close liaison between the Air Force, the intelligence community, and the R&D agencies, to keep the development of EW equipment as advanced as possible. It called for the establishment of a capability to produce a few critically-needed items on a crash basis, thus preceeding by six years the publication of Air Force Regulation 80-32, which formalized the "Quick Reaction Capability". Insofar as it was possible, airborne equipment should be engineered so as to function as an integrated system with the aircraft, thus recognizing the need to consider an aircraft's EW capability as an integral aspect of its overall combat capability, instead of looking at EW as an "add-on" for use when and if needed. Finally, airborne equipment should function as automatically as possible, to reduce manpower needs, and it should be designed to be

[37]Letter, Army Air Force HQ to Commanding General, Air Materiel Command, 26 September 1946, subj: "Proposed Countermeasures Equipment Research and Development Plan", 218-31 in AFHRA. This decimal (218) contains AMC records.

rapidly interchangeable with other EW equipment in standard equipment racks, so that the Air Force could quickly react to changing threats and operational needs.[38]

The third part of the plan concentrated on specific equipment requirements, and included intercept equipment, jammers, and deception devices. In a remarkably prescient section on intercept equipment, the plan stated that "It is believed that urgent need will exist for quick direction-finding in future tactical air force operations.... [and] equipment for accurate homing on enemy installations and airborne electronics equipment is needed." Two decades later, aircrews flying "Wild Weasel" missions against North Vietnamese radar and SAM sites would heartily agree that such equipment was, indeed, urgently needed. The section on jamming equipment, however, was not as farsighted. It listed the proximity fuze as the greatest threat, and the daily office diaries of the Air Communications Office for 1946 and 1947 contain more references to work on a jammer for proximity fuzes than any other piece of EW equipment. The plan made only a weak comment about R&D against the guided missile threat, even though elsewhere the plan specifically noted the increasing threat such weapons would pose. The plan did call for a series of airborne jammers capable of nullifying enemy gun-laying, early warning, ground controlled intercept, and airborne intercept radars, as well as developing a communications jammer for employment against enemy communications links. The plan also correctly noted that deception sometimes is more effective than outright

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[38]Ibid.

jamming, and it recommended continuation of the R&D program for chaff. Finally, the plan stressed the need to approach EW as a search for systems, not individual pieces of hardware.[39]

Precisely what impact this plan had on the Air Force EW program is difficult to determine, but there is little documentary evidence indicating that it shaped policy in any significant manner. Even so, many of its major points were proven out in the coming years. By the end of 1947, however, the quality of any plan for future R&D was of less immediate importance than recovering from the confusion and malaise which accompanied demobilization. The loss of funds, equipment, people, and even motivation, coupled with a fragmented R&D effort, imposed a set of limitations on the Electronic Warfare program that might have been avoided and probably could at least have been mitigated. What was needed was for one of the Air Force's combat elements to call actively and aggressively for improvements to its EW capability. Fortunately, this was about to happen.

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[39]Ibid: ACO Daily Diary, numerous entries throughout 1946 and 1947; the project officer on proximity fuze issue and tests was Captain Hugh Winter, who was the office's most experienced and knowledgeble ECM expert, an indication of the importance attached to it.

CHAPTER FOUR

THE REBIRTH OF EW: SAC, 1948-1950

After two years of seemingly-chaotic activity and change, the birth of the Air Force as an independent service also marked the rebirth of its Electronic Warfare capability. Leading the way was the Strategic Air Command under its new commander, General Curtis E. LeMay. Recognizing the importance of EW to its wartime mission, SAC began to push seriously to improve its ability to employ EW in combat. Starting with the identification of equipment requirements and the establishment of a training program for personnel to conduct EW operations, SAC took the initial steps to obtain the equipment and people which its new bomber units would need. By 1950 and the outbreak of the Korean War SAC was leading the way in Electronic Warfare.

Thinking About EW

Many Air Force officers were first exposed to EW in the pages of the service's new professional journal, the Air University Quarterly Review (AUQR), or in one of the Air Force's officer schools, such as the Air Command and Staff School or the Air War College. Articles in the AUQR highlighted the topic for thoughtful officers in the late 1940s. In "Electronics in Air War", Colonel Wendell Bowman noted that "In strategic air operations the role of electronics clearly spells the difference between success and failure", because air defenses would increasingly rely on radar. He failed to note, however, that electronics had indeed become a weapon and was not just an accessory.[1] Colonel Fred Moore, in his article on "Radio Countermeasures", cogently noted four factors which would involve RCM and bomber self-defense: 1)the high speeds and altitudes at which future bombers would operate; 2) bomber formations would be small; 3)strategic air operations would be concentrated in a brief period of time as short as three months; 4) the air defense system would have only a few minutes in which to react and oppose the bombers. He also clearly identified the three critical parts of an effective operational EW program: sound electronic intelligence (ELINT) on the enemy, effective EW equipment, and well-trained personnel to operate the devices as well as plan and and conduct operations. Finally, he called for the immediate development of an RCM program in order to have an effective capability in the future.[2] Although both articles were essentially introductory overviews of EW they served to make it accessible to the Air Force at large.

In contrast, officers at some of the Air Force's officer schools received a more practical and in-depth look at EW; unfortunately, this could only reach a limited number of officers. Those at the Air War College in early 1947 were exposed to EW during their exercise on "Technology as Applied to Military Apparatus", and a fifth of them were assigned to evaluate the impact of radar countermeasures on future air strategy and tactics. This was a sound step: the drawback was that this exercise was

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[1]Wendell V. Bowman, "Electronics in Air War", Air University Quarterly Review, Vol 3, #1, (Summer, 1949), p. 52.

[2]Frederick E. Moore, "Radio Countermeasures", Air University Quarterly Review, Vol 2, #2, (Full, 1948), pp. 62-66.

monitored by the Research and Development division instead of the one reponsible for strategy and operations, thus making EW appear to be a future item rather than one offering immediate combat capability.[3] Another drawback was that AWC had a civilian scientist lecture on EW instead of a combat leader who had employed it during the war. This contributed to the students' perception of EW as a technical device for possible future employment rather than as a weapon that had already been extensively employed in combat. The 1950 course outline for the "Technology" bloc of instruction did not include EW and it was apparently dropped from the curriculum. The AWC reading list for 1950 did not mention it either. The Air Command and Staff School curriculum for 1949 devoted only one hour to ECM, and ignored it entirely the next year. The impression one is left with is that although EW received some coverage in the AWC program from 1947-1949 it was not done as effectively as it might have been, and it passed from active consideration in the curriculum.[4]

Some of the officers attending the Air Command and Staff School (forerunner of today's Air Command and Staff College) in 1948 and 1949 explored the new field of Electronic Warfare in their research studies. Some looked at EW from an air defense perspective, others at the use of ECM in future aerial warfare, and one examined the use of ECM for strategic bomber self-defense. Several noted that no new ECM

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[3]Air University History, Vol 2, pp. 247-248, and Vol 4, Air War College Instructional Circular #47-12, 1 March 1947, Problem #12 "Technology as Applied to Military Apparatus", November 1945-June 1947, 239.01, in AFHRA.

[4]Air University History, July 1947-June 1948, July 1948-June 1949, July-December 1949, January-June 1950, 239.01, AFHRA.

equipment had been developed since World War II, and they reiterated the necessity of a revitalized research and development (R&D) program. The need for new equipment, trained personnel, and plans for operational employment was also highlighted.[5]

One paper in particular, "Electronic Countermeasures for the Defense of the Strategic Bomber" by Lieutenant Colonel Frank Luschen, identified several key items. He noted that anti-aircraft fire would become increasingly less important to future air defense against strategic bombers, because the high speed of future jet bombers would greatly reduce the time they were vulnerable to AAA fire; this, when combined with the susceptibility of the anti-aircraft fire-control radars to ECM, meant that the threat from flak would be greatly reduced. The primary near-term threat would come from interceptors, whether in daylight or darkness. Yet they, too, depended on radar for their ability to intercept and attack the new jet bombers. Colonel Luschen noted that tests conducted at the Air Proving Ground (Eglin Field, Florida) demonstrated the vulnerability to jamming of the ground-controlled intercept (GCI) radar and the VHF voice communication link between fighter and ground controller. The need for such a capability was not lost on SAC, which issued a formal requirement letter in February 1948 citing the need for complete VHF and UHF jamming coverage. In the long term

[5]Research papers submitted to the Air Command and Staff School of the Air University: Major J.A. Gibbs, "The Requirements for Electronic Countermeasures Units in an Adequate Air Defense System", 239.04349A-161, May 1949; Lieutenant Colonel Frank L. Luschen, "Electronic Countermeasures for the Defense of the Strategic Bomber, 239.04349A-271, May 1949; Major Mario E. N.ccolini, "The Role of Electronic Countermeasures in Future Aerial Warfare", 239.043498-282, October 1949; Major F.R. Ramputi, "The Use of Electronic Countermeasures in Future Aerial Warfare", 239.04348, December 1948; all in AFHRA.

the guided missile might well be the greatest threat to SAC bombers, and Colonel Luschen noted three different types of missile control systems for which ECM systems were needed: command guidance, in which a ground controller directed the missile; beam riders, in which the missile autonomously tracked a separate radar beam; and a homing system, in which the missile used emissions from the target itself (heat, light, sound, etc) to locate and home on it. The possibility that strategic bombers would in the future operate alone meant that each must be fully provided with a self-contained ECM capability and that it not require manual operation but be completely automatic. Noting that 8th Air Force had to pool its combined ECM resources simply to equip half a dozen bombers for a test at the Air Proving Ground, he called for renewed support for an expanded R&D program, new equipment, trained personnel and an improved ELINT collection capability. It is impossible to determine how much impact Colonel Luschen's paper had on the Air Force EW program: what is certain is that he had accurately described the current status of the program, as well as outline several crucial future requirements. He had also identified the Air Force organization which was to play the key role in EW for the next several years: the Strategic Air Command.[6]

SAC Before LeMay

A common perception of American military capability during the half-decade immediately following World War II is of strategic airpower, possessing a monopoly

[6]Luschen, "Electronic Countermeasures for the Defense of the Strategic Bomber", pp. 12-25.

on atomic weaponry and singlehandedly holding the Russians at bay. While there is an element of truth to that view, it is also true that the ability of SAC to deliver a nuclear knockout blow to the USSR was extremely limited. In 1948, for example, the B-29s that President Truman sent to Europe in response to the twin crises in Czechoslovakia and Berlin actually had no atomic capability: they were from the 28th, 301st and 307th Bomb Groups, which had not been modified to carry atomic weapons.[7] In part this was the result of decisions by President Truman which emphasized budgetary austerity at home and the overriding strategic necessity of financing European economic and political recovery and stability. The Air Force was forced to reduce its planned 70 group force to only 48 operational groups, and the continuing shortages in men, aircraft and materiel severely limited its combat capability.[8]

In other ways, however, many of SAC's limitations were self-imposed, the result of faulty management and poor leadership. With General George Kenney, SAC commander-in-chief, devoting most of his time to activities away from SAC, his second in command, Major General Clements McMullen, actually set the policies and ran the command much of the time. McMullen believed in pilots: he was convinced that SAC had too many officers, and that the command would function more efficiently if most of the non-flying officers were shipped elsewhere. For example,

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[7]Borowski, A Hollow Threat, pp. 126-128.

[8]Wilson, "Air Policy Commission", p. 259.

under Air Force Regulation (AFR) 20-15 a very heavy bombardment wing was authorized 287 officers, but McMullen felt that only 227 were needed: most of the 60 superfluous officers were non-flyers. During the summer of 1948, in the midst of the Berlin Crisis, the 509th Bomb Group, virtually the only organization capable of conducting atomic operations, actually reassigned one-fourth of its non-flying officers. McMullen's leadership philosophy was "Give them half of what they asked for, work them twice as hard, and they will get twice as much done." In an Air Force which in mid-1948 still lacked 30% of its authorized officer strength this enforced exodus of officers seriously eroded the command's strength.[9]

McMullen's proposed solution was called "Cross Training", which had its origins in the 1930s. In the small pre-war Air Corps many of the flying personnel could perform a variety of tasks: pilots served as navigators, navigators as bombardiers, etc. McMullen insisted on trying to impose this philosophy on postwar SAC, with disastrous results: morale plummeted, the proficiency of flight crews to perform their individual specialties declined, and SAC combat capability plunged even lower. McMullen had tried to reshape what was intended to be a combat-ready force into his ideal of one stressing leanness and efficiency, but in the process had neglected realistic training in favor of a more simplified regime in support of cross-training. Most practice bombing, for example, was done visually at day from below 25,000 feet, yet

[9]Borowski, A Hollow Threat, pp. 65-66, 146-149; Report of the Secretary of the Air Force to the Secretary of Defense for Fiscal Year 1948, (Washington, DC: GPO, 1948), p. 146.

SAC's wartime mission would probably call for bombing by radar at night and from above 25,000 feet. The result was a force which looked good on paper but whose ability to penetrate to a real target against determined defenses and accurately drop real bombs under a variety of wartime conditions was questionable.[10]

The most immediate requirement SAC had was for aircraft. In 1947 SAC still relied on fewer than 200 B-29s, although it would soon begin to receive some B-50s (an upgraded version of the World War II-era B-29) and the new, long-awaited-and-hotly-debated B-36, with true intercontinental range. Both SAC and the Air Force were approaching a watershed in aircraft capability requirements. None of SAC's existing or planned bombers had an EW capability designed into the airplane. In 1944 the "Airplane Model Specification" for the planned B-36 listed only eleven crew members, none of whom was assigned the task of operating any ECM equipment, and in December 1947 the USAF Aircraft and Weapons Board's "Estimated Military Characteristics of Heavy Bombardment Aircraft" stated that "No radar countermeasures is required". By the next year, a memo by the Director of Research and Development on "Military Characteristics of Bombardment Aircraft" failed to mention ECM at all.[11]

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[10]Borowski, A Hollow Threat, pp. 68, 147-148; Borowski, "Air Force Atomic Capability from VJ-Day to the Berlin Blockade--Potential or Real?", p. 109.

[11]AC/AS-4, Chief Research and Engineering Division, to Commander, AMC, 14 April 1947, in RG 341, VIII/D5, DCS/Development, Director of R&D, Box 170, Section 28; USAF Aircraft and Weapons Board, "Estimated Military Characteristics of Heavy Bombardment Aircraft", 6 December 1947, in RG 341, VIII/D5, DCS/Development, Director of R&D, Box 170, Section 29; Memo same title and originator, dated 5

Yet SAC clearly recognized the need for ECM in its new bombers. In November 1947 SAC forwarded to the Chief of Staff a study on future ECM requirements which forcefully stated the case for an improved EW capability. Its opening statement of the general situation is worth quoting:

> "..... it is imperative that the Air Forces develop and incorporate into their operational plans an effective electronic countermeasures program. This program may no longer be treated as a special service to the operational unit but must be considered as one of the normal weapons of both offense and defense for the protection of the aircraft and its crew as well as for the confusion of the enemy."[12]

The study noted that much of the Air Force's existing equipment was obsolete, and that each heavy bomber "must be equipped with lightweight automatic, high-powered, search-spot jamming systems capable of screening the...aircraft." This statement was crucial, because it established several of the characteristics which SAC would continue to emphasize; lightweight, small, high powered, automatic, etc. The call for a self-screening capability was actually the start of a tactical ECM doctrine, because it implied that one tactic which SAC might use involved aircraft attacking alone and unescorted. The study even called for a capability to "absorb or cancel...radar energy and thus make the aircraft invisible to radar", which in effect was the Air Force's first

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October 1948, Box 170, Section 31; all in NARS, Washington, DC.

[12]Staff Study, "Electronic Countermeasures Requirements", 10 October 1947, in Strategic Air Command History, Vol 5, Chapter 5, (published as a SAC Historical Study, "Development of Strategic Air Command Electronic Countermeasures Program"), K416.01, January-June 1951, AFHRA.

requirement for "low observable" or "Stealth" technology! The study urged the Air Force to develop an ECM program and to "profit from the mistakes of the last war in which this program was always treated as a special function. In future operational planning we must regard electronic countermeasures as a major operational weapon."[13] Sending this study to the Chief of Staff was a clear statement that SAC realized it needed an effective EW capability, and that it meant to get one.

Rebuilding the Personnel Cadre

The EW program not only lacked ECM equipment and airframes: the dearth of experienced ECM officers which followed demobilization meant that the EW program literally had to start from scratch. The Air Force had determined in early 1946 that there was no need for an extensive RCM program, and officers holding MOS 7888 (radar observer/RCM) could be released; not until later that year was that decision reversed, by which time virtually the entire cadre of countermeasures specialists had left the service. Throughout the entire Air Force there were perhaps a dozen officers experienced in radar countermeasures operations. Not surprisingly they were concentrated in SAC, because SAC had the few remaining B-29 units which had employed countermeasures during the war. The lone ECM officer at headquarters SAC, Captain Les Manbeck, began an Air Force-wide program to identify and recall officers with EW experience. His counterpart at 8th Air Force, Captain Frank Lindberg, actually had his orders releasing him from active duty cancelled the day he

[13]Ibid.

was due to sign out! Others were not so lucky: as Les Manbeck described, they "were assigned to other communications-electronic functions--or worse."[14] This provided a small nucleus of officers with EW experience, but it obviously was not the long-term solution: the Air Force needed a more permanent source for EW officers.

In August 1947, therefore, the Air Force acted to reestablish a training program for EW officers. Training would be accomplished in two major phases, a ground training course administered by the Air Training Command (ATC), and a series of training flights given by SAC. Seven officers were to be entered into the program per month, with half of the graduates going to SAC. To enter the course officers had to be graduates of the 42-week long course for Electronics Officers (MOS 0141). Officers who completed this gauntlet of courses would be highly trained, as they would need to be, because the Radar Observer/RCM was still a jack-of-all-trades when it came to EW. As SAC Regulation (SACR) 50-8 "Training" pointed out, the RO/RCM was responsible for operating radar intercept and jamming equipment, developing operations plans and tactics, supervising maintenance on the ground and actually performing maintenance on EW equipment while in flight.[15]

[14]Lester Manbeck (Colonel, USAF, Ret.), letters to author, 4 December 1988 and 31 March 1989; Frank Lindberg (Colonel, USAF, Ret.), letter to author 16 May 1989 and telephone interview, 3 June 1989.

[15]Letter, HQ USAF to SAC, 7 August 1947, subj: "Flight Training for Radar Observers/RCM, SSN 7888", in "Development of SAC ECM Program"; Air Training Command History, Vol 3, pp. 572-574, 686, January-December 1947, 280.01; SAC Regulation 50-8, "Training", in SAC History, Vol 3, January-December 1947, 416.01; all in AFHRA.

The problems involved in actually establishing this training plan well describe the situation of the Air Force EW program. The 324th Photo Reconnaissance-Radar Countermeasures Squadron would be assigned the task of providing the flying phase of the training program, but in late 1947 the 324th existed essentially only on paper: it needed everything, including people, aircraft, equipment, training guides and materials, even a base! To keep it close to the majority of radar installations in the country the 324th would be based at Fort Dix, New Jersey, at what is now McGuire AFB. The 324th's parent unit, the 311th Reconnaissance Wing, had moved from Florida to Andrews AFB, near Washington, DC., in May, and had the only two aircraft in the inventory which could perform ELINT operations and training: a B-17 which had been conducting operations throughout much of 1946 and 1947, and the prototype of a B-29 Ferret.[16] The ground training would be accomplished at the radar school at Keesler AFB, in Biloxi, Mississippi. At the start of 1947 it was still at Boca Raton, Florida, but a planned move to Biloxi was both accelerated and hampered by a devastating hurricane in September 1947, which caused sea water damage to about 40% of the radar school's equipment.[17]

Although the flight training phase was supposed to begin operations shortly after

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[16] Memo, SAC/Communications-Electronics Division to Staff, 21 August 1947, subj: "Action Necessary to Implement Training Program for Radar Observer/ RCM Training", in "Development of SAC ECM Program", K416.01; Unit Historical Report, 311th Reconnaissance Wing, February 1948, in AFHRA.

[17] Much of the damaged equipment was saved, however, by drying it in a makeshift homemade electric oven! See the 1947 Unit Historical Report for Boca Raton Army Airfield (AAF), 280.87-22 and Keesler AAF, 285.18-16, -17, and-18 in AFHRA.

the first group of officers completed ground training in April 1948, conditions at McGuire made that impossible. One of the initial cadre of instructors, Lieutenant Harry Smith, flew over the base and said it "was a shambles", and when he arrived for duty in June 1948 he said it was "even worse than it had looked from the air". Despite the fact that the tables of organization and equippage (TO&E) authorized twelve instructor crews, each with six ECM officer instructors, the 324th had only one such crew, and it was the only crew in the entire Air Force authorized to administer flight training in ECM operations. Obviously, the 324th's first job would be to train its own instructor force, and about half of the graduates of the first few classes stayed with the 324th. The burden this placed on the initial instructor cadre was immense. Lieutenants Harry Smith and Joe Wack not only had to train the students but also supervise virtually all of the maintenance on the ECM equipment. The end of 1948 saw the 324th squadron short 90 officers; not until mid-1949 did it even reach 85% of its authorizations (122 out of 149).[18]

The first group of officers entered the ten-week long ground phase on 5 May 1948, and continued on to the flight phase at the end of July. One problem area concerned the qualifications of those officers assigned to this and other electronic training programs. Many lacked the necessary educational background and had no

[18]Harry Smith Interview Transcript in Association of Old Crows (AOC) Archives; Letter, Commander 311th Air Division, Reconnaissance, to Commander SAC, 26 August 1948, subj: "Flight Training for Radar Observer, RCM 7888", in "Development of SAC ECM Program"; Unit Historical Reports, 311th Air Division, Reconnaissance, May-August 1948 and September 1948-October 1949, in AFHRA.

experience in electrical concepts, since before mid-1951 virtually any officer could be assigned to these programs. One of the more tragic cases occured in early 1950, when an older student officer in the Electronics Officer course committed suicide after having difficulty with the academics. This lieutenent had served in communications for most of his military career, but had been a coal miner in civilian life and had left his small high school over two decades earlier without graduating. Although this may have been the most egregious example of malassignment into the Electronics program, it was also true that nearly a third of the officers in the Electronics program overall did not request assignment into it and entered it only grudgingly.[19]

The ECM training program was not immune to problems with student officers, and it too had its share of students who did not possess the proper academic background. A second problem concerned the military background of some of the students, particularly their rank and aeronautical ratings. By August 1948 two of the eight officers who had completed the ground training phase were majors and thus too senior to be effectively used as ECM operators. Worse, not only were some of the following students also too senior to be used, some were rated pilots. They may have been assigned as a result of the "Cross Training" program, but however they got there, they hated it, as noted by Lt. Joe Wack, one of the initial instructors, who said that the "ex-pilot Ravens [ECM crewmembers]...had little or no feel for the job and simply did

[19]Unit Historical Report, 311th Air Division, May-August 1948; Keesler AAF, July-September 1948, 22 April-June 1950, 285-18-21; Air Training Command History, Vol 1, p. 389, July 1950-June 1951, K280.01; all in AFHRA.

not like flying in the backs of airplanes....As time went on almost all the ex-pilot Ravens managed to get transfers to other posts, or else left the Air Force. We were better off without them." In the process, however, they took up scarce training slots and wasted critically short instructor and aircraft resources.[20]

Another problem area concerned how these ECM operators would fit into the Air Force's personnel system. General Kenney expressed his concerns to the Chief of Staff in September 1948, noting that some system of career planning for the ECM specialists was needed. Under the current system they could never become senior officers because their speciality was too narrow and technical, so he suggested the creation of a new grade, "air technician", in which they would serve for five years. Fortunately, this was never acted on, as it would have created a military speciality neither officer nor enlisted and even further isolated the ECM cadre from the mainstream of the Air Force. The "betwixt and between" status of ECM was further compounded by the issue of aero ratings, such as pilot and navigator. The fact that graduates of the two-phase ECM course did not receive permanent aero ratings, even though their primary duty was on board a combat airplane, negatively affected both morale and recruitment into the field. This was especially true because of the very high level of education and training possessed by many of the EW officers. As the commander of the 91st Strategic Reconnaissance Group observed, "many of these

[20]Letter, Commander 311th Air Division to Commander SAC, 26 August 1948, subj: "Flight Training for Radar Observer, RCM 7888" in"Development of SAC ECM Program"; both in AFHRA; Joseph Wack Interview Transcript, AOC Archives.

officers are college engineering graduates or have had several years of experience in communications and radar and are thus highly qualified...to formulate policy, plans and doctrine for Electronic Warfare." He urged that these officers be granted permanent aero ratings and flight pay, but his request was not approved until mid-1951.[21] These problems well illustrate the uncertain status which EW enjoyed in the Air Force, which hampered efforts to attract and retain good people. Within one command, however, its status was about to get a real boost.

SAC: the LeMay Era Begins

For a variety of reasons which need not be recited here, General Kenney was in effect fired in October 1948: suffice to say that Air Force leaders were convinced that SAC needed a commander who could make it into a first-rate combat force, which in mid-1948 it was not. General Curtis E. LeMay was perhaps the ideal officer to take on that task. A proven combat leader with experience against both the Luftwaffe and the Japanese, General LeMay was committed to two intermediate objectives that he felt vital to improving the combat capability of the Strategic Air Command: raising morale, and making training more combat oriented. Without significant improvements in both areas, he felt, SAC could not progress. Literally from the day he took command on 19 October 1948, General LeMay emphasized realism in training. The

[21]Letter, Commander SAC to CSAF, 21 September1948, subj: Endorsement of 21 August 1948 letter from 311th Air Division Commander, in "Development of SAC ECM Program", & pp 31-32 of study; Air Training Command History, Vol 1, page 359, July 1950-June 1951, K280.01; Letter, 91st Strategic Recon Group to 91st Strategic Recon Wing, 9 September 1949, subj: "Permanent Aeronautical Ratings for Radar Observer, ECM, SSN 7888", in "Development of SAC ECMProgram"; all in AFHRA.

"old" methods stressed mechanics, but left out any aspect of what the typical combat mission might require. General LeMay set about changing that. To make his point that the entire command needed work he planned an operation to prove how little actual combat capability the command had. One night in January 1949 he sent the entire command, over 150 aircrews, on a simulated atomic strike against Dayton, Ohio. The mission would be conducted at night, not during daytime when most SAC training missions had been flown, and they would "bomb" their targets by radar from an altitude above 25,000 feet, also not in accordance with the "old" methods. To make matters worse (or better: it depended on your perspective!) weather over Dayton that night was poor, with intermittent thunderstorms. The results completely vindicated LeMay: in his words, "Not one airplane finished that mission as briefed: NOT ONE." His message was clear: to become a force ready to go to war at a moment's notice and conduct strategic bombardment operations anywhere in the world, SAC had a lot of work to do.[22]

The importance to the EW program of this new attitude was crucial: General LeMay and his staff were combat leaders who were ready to support those capabilities and technologies which promised to improve SAC's ability to successfully penetrate air defenses, reach the target, bomb it accurately, and return home able to accomplish another mission. He and his staff, most of whom had been in XXI Bomber Command and had seen ECM in action against the Japanese, knew that EW could help them

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[22]Borowski, A Hollow Threat, pp. 149, 163-167.

achieve their wartime mission, and they were ready to support it. Les Manbeck, chief of the ECM branch at SAC, stated that the key senior staff officers, including General LeMay, General John Montgomery (DCS/Operations) and General Jack Catton (Director of Plans) "were very receptive to ECM. My biggest problem [was that] I had sold ECM too well conceptually and had very little hardware to show them." This support extended to SAC's subordinate organizations as well, notably 8th Air Force, where Lieutenant Frank Lindberg, who was Manbeck's counterpart, also gained the support of the staff, including the commander, General Roger Ramey, and several key officers such as General William Blanchard (future SAC/DO) and General John Ryan (future CSAF).[23]

Less than two weeks after General LeMay took command of SAC, General Ramey forwarded to him a detailed examination of 8th Air Force's ECM requirements. He noted the inadequacy of existing ECM equipment and observed that no "adequate action" had been taken on the letters and tactical requirements which 8th AF had submitted. He weighed the cost of supporting an adequate ECM program, including R&D of equipment, training of crews, and procuring operational equipment, against the potential costs of failing to deliver any of the small number of atomic bombs and determined that the cost of an effective ECM program to be "nearly negligible." Among the specific equipment requirements he cited were an improved system for dispensing chaff, and a five-fold increase in the spot-jamming equipment authorized

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[23]Lester Manbeck, letter to author, 31 March 1989; Frank Lindberg telephone interview with author, 3 June 1989.

each bomb group. He also called for more ECM personnel, noting that under the peacetime tables of organization 8th AF units were not authorized any ECM personnel. Given General LeMay's emphasis on constant readiness, this was a shortcoming which would likely receive some high-level attention in the future. Finally, he urged that the highest priority on supply of equipment and personnel be accorded to the 8th AF and especially the 509th Bomb Group, since this was the only existing atomic strike force.[24] A few days later, even before SAC had the opportunity to indorse General Ramey's letter and forward it to headquarters USAF, the office of the Assistant DCS for Atomic Energy noted that providing "complete ECM protection to the atomic striking force is a matter of desperate urgency" since the B-29s had no ECM protection above 1400 MHz, leaving them vulnerable to Russian radars which were known to operate above that frequency. It strongly urged that the Air Force procure "at once. .. by whatever means are necessary" at least two APT-9 jammers for each SAC bomber, which would provide a jamming capability against radars in the 300-2500 MHz frequency band. Combined with General Ramey's report and the indorsement from SAC, powerful support was being given to improving the Air Force EW program.[25]

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[24]Letter, Commander 8th Air Force to Commander SAC, 30 October 1948, subj: "Electronic Countermeasures Requirements", in "Development of SAC ECM Program", K416.01, in AFHRA.

[25]Letter, SAC DCS/Operations to CSAF, 30 November 1948, subj: Endorsement of 30 October 1948 letter from 8th AF Commander; Letter, HQ USAF, Assistant - DCS/Atomic Energy to Assistant DCS/Requirements, 3 November 1948, subj: "ECM Equipment", both in "Development of SAC ECM Program", K416. 01, in AFHRA .

Such support was crucial, for a SAC history of ECM development assessed the command's ECM capability at the time as "practically nonexistent". In May 1949 General LeMay asked his Communications-Electronics office for a status report on EW. Specifically, he asked three questions: 1)what ECM equipment was then available for employment against a well-defended target; 2)what was the ECM capability of both the B-29 and B-36; 3)what could be accomplished within 30, 60 and 90 days to improve SAC's capabilities? The answers were discouraging. The memo from the C-E office to General LeMay noted that in any well defended area, SAC bombers would encounter radars in the L band (400-1500MHz), S band (2700-3350MHs), and X band (9000-11,000MHz), proximity-fuzed AAA, and VHF and possibly HF voice communication for fighter control. To counter these, SAC had some World War II-era jammers in the 30-1400 MHz range, and about 25 jammers effective in the S band frequency range (2700-3350MHz). Between 1400 and 2700MHz, and above 3350MHz, SAC had nothing, and could not expect to obtain operational equipment for a year in the lower frequencies, and two to three years for the higher ones. A jammer for use against proximity fuzes was not yet available. Chaff was available to cover the frequencies between 600 and 3000 MHz, but again nothing was available for employment in the X band. Chaff dispensers were available to equip six B-29 groups, but engineering data was not yet available for installing chaff dispensers in the B-36. The memo closed with the dour observation that "The electronic countermeasures capability of SAC in 30, 60 and 90 days will be esentially the same as at present." In other words, SAC had only a limited ECM capability, with slight prospects for a significant near-term improvement.[26]

The new leadership at SAC immediately set out to change this. Les Manbeck spent much of his effort during the first few years after the war preparing studies on the employment of chaff and jammers and and the R&D requirements for new equipment. SAC was preparing to act on the requirements which he and Lindberg had developed. On 1 July 1949 General Thomas Power, LeMay's vice commander, notified the Air Force Director of Training and Requirements that SAC needed a new and ambitious ECM system, capable against "any and all electronic defense systems". He enumerated the critical points in the defensive electronic net against which a bomber's ECM capability must operate, including detection and tracking of the bomber, tracking by defensive systems, and guidance and/or homing of defensive systems. He then set forth the broad guidlines for a two-phase EW program that would provide near-term, interim, and long-term automatic capabilities. The interim capability would be based on equipment currently available or under development, but would provide only minimum protection to existing bombers. The long-term solution was the development of a fully automatic ECM system, including receiver, analyzer, transmitter, and antennas. Such a system would, if successful, obviate the need for a ECM operator in the aircraft.[27] This remained a persistent but elusive objective of the

[26]"Development of SAC ECM Program", pp. 74-75; Memo, SAC/Communications-Electronics Division to Commander SAC, 23 May 1949, K416.01; both in AFHRA.

[27]Lester Manbeck letter to author, 31 March 1989; Frank Lindberg telephone interview with author, 3 June 1989: Letter, Deputy Commander SAC to HQ USAF/Director of Training and Requirements, 1 July 1949, subj: "Airborne ECM

EW program; as shall be seen, a later decision to "hedge a bet" and redesign the B-52 to include an ECM operator would be a critical success.

The remainder of 1949 saw SAC reaffirm its earlier call for an improved and expanded EW capability, with a constant flow of correspondence using language such as "imperative...urgent...least possible time...1A priority". In mid-January 1950 SAC undertook a detailed examination of its EW program: where it stood at that moment, where it would soon be, and what the future held. The report noted that the only equipment which SAC's fourteen bomb groups currently had was the same as that available four years earlier at the end of World War II. The relatively small number of bombers available and the probably small size of bomber formations meant that manually-operated spot jamming would be required: there were insufficient forces to employ large-scale barrage jamming. The report next outlined the interim ECM program and examined what capabilities would exist in the near future. Modest improvements would be available in several areas, but major problem areas still existed. Some of the equipment under development was too bulky or heavy for existing aircraft; the A1 chaff dispenser would accept all eight types of chaff under development, but the dispenser itself was unreliable and prone to malfunction. The APR-4 receiver, a critical component for intelligence gathering, was in such short supply that "civilian markets are now being surveyed to reclaim servicable models". The future ECM program was devoted to the two new bombers, the B-47 and B-52.

System to meet SAC Requirements", in "Development of SAC ECM Program", K416.01, in AFHRA.

The existing aircraft would employ manned ECM systems exclusively, but for the new bombers SAC hoped to have either automatic systems or manual ones that had an instantaneous tuning capability, as well as unattended sweep jammers. The report concluded with a list of equipment tests which were scheduled for the near future.[28]

Two months later, General Power asked the C-E staff for additional information on the status of several pieces of equipment referenced in the earlier report. He noted that in 1948, nearly two years earlier, SAC had established a requirement for an S-band jammer: it was not yet available. In February 1948 SAC stated its need for a communications jammer, to block fighter control channels: it was not yet available. In November 1947 SAC outlined its chaff requirements: new chaff types were still undergoing testing. Worse, 15th Air Force had just recommended that the protoytpe chaff dispenser designed by Air Proving Ground be rejected as unsuitable. This left SAC with only the old A-1 dispenser, which as noted earlier was prone to malfunction. The situation became so serious that in November 1950 General LeMay wrote directly to the Air Materiel Command commander, General Ben Chidlaw, outlining his concerns. He reminded General Chidlaw that the chaff dispenser requirement for the B-29 and B-50 went back two years, and a satisfactory model had still not been received. The B-36 requirement was a year-and-a-half old, yet a

[28]Letter, Deputy Commander SAC to HQ USAF/Director of Requirements, 4 October 1949, subj: "Proposed Military Characteristics for ECM System for Bombardment Aircraft" and follow-up letter, 9 December 1949; SAC C-E Division, "Status of the ECM Equipment Program for Bombardment Aircraft", 23 January 1950; all in "Development of SAC ECM Program", K416.01, in AFHRA.

satisfactory engineering drawing had not even been produced. The result, according to General LeMay, was that SAC had no chaff capability in its heavy bomber force (the B-36s) and about a 10% capability in the 60% of the medium bombers (B-29s and B-50s) which were equipped with chaff dispensers. Since "Chaff is our most reliable ECM" system, LeMay asked Chidlaw to do whatever he could to speed up the acquisition of suitable chaff dispensers for the bomber force.[29] The inescapable conclusion drawn from these several studies and reports is that the SAC ECM program was not in much better shape at the end of 1950 than it had been when General LeMay first asked for a status report in by 1949, at least in terms of equipment.

The personnel situation was improving, in part because of the training program, which continued to expand and develop. The graduates of the program were needed at all levels of the Air Force, but primarily at the operational units, particularly by the 9th and 91st Recon Wings, which would need over 200 officers with MOS 7888 by summer 1950. This was due to the expansion of the Air Force ELINT program, which placed the 324th squadron at McGuire in a no-win situation. A series of name changes illustrated the nature of the problem. In October 1948 the 324th went from being a "photo" recon to a "strategic" recon squadron, and in April 1949 from being the 324th SRSq/ECM to the 324thSRSq/Electronic, to avoid misconceptions about its

[29]Memo, SAC/Communications-Electronics Division to Deputy Commander SAC, 21 March 1950, subj: "Status of ECM Program"; Letter, 15th Air Force DCS/Operations to Commander SAC, 9 March 1950, subj: "Random Chaff Dispenser"; Letter, General LeMay, Commander SAC to General Chidlaw, Commander AMC, 15 November 1950; all in "Development of SAC ECM Program", K416.01, AFHRA.

mission, which was ELINT collection, not radar jamming. This was also demonstrated by the flight training program. Although the original plan had intended for recon and jamming to receive an equal weight of effort during training, it did not work out that way. Each student was to receive 66 hours of airborne training, spread over the course of ten flights. The first two flights were familiarization missions, totalling nine hours. Five of the flights, totalling 45 hours training, were devoted to ferret or ELINT operations, while the remaining three flights, of 12 hours duration, were jamming missions. The 324th was an operational squadron with a real-world ELINT mission, and the training program was proving to be a significant drain on its limited resources.[30]

The shortage of ECM officers was exacerbated in mid-1949 when the Air Force adopted the 48 Group Program. Earlier projections had indicated that by mid-1950 the Air Force might be short about 100 officers with MOS 7888, but the 48 Group Program nearly quadrupled that shortage, with 437 radar observer/7888s authorized on 30 June 1950 but short 397 of them. The Air Force Director of Training and Requirements notified the Air Training Command that the ECM course needed to be expanded and the input of students increased. The suggested solution was to delete the requirement for entrants to be graduates of the Electronics Officer course (MOS 0141) and to incorporate into the ground training phase of the program those sections

[30]Unit Historical Report, 311th Air Division, September 1948-October 1949; Letter, SAC to 311th Reconnaissance Wing, 4 December 1947, subj: "Flight Training for Radar Observers, RCM, 7888", in "Development of SAC ECM Program", K416.01, in AFHRA.

which were directly applicable to ECM. This would lead to a lengthening of the ECM course itself, but an overall decrease in the time required to train an ECM officer. The basic electronics course, for example, included 1260 hours of academics, a great deal of which did not pertain to ECM: LORAN navigation, radar bombsights, radar altimeters, etc. Air Training Command adopted this approach, and on 7 December 1949 the first class started under the new, 36-week long program. The first twenty-two weeks covered essential electronics, while the remaining fourteen weeks concentrated on ECM. Twelve students were to enter every two weeks, for an annual total of over 300 students.[31]

This did nothing, however, to ease the situation with the 324th squadron. The impact of worldwide operational ELINT missions and the paucity of RB-29 ferrets with which to train meant that even the very small classes (the first three had only 13 officers total) fell behind in their training. In April 1949 the commander of the 311th Air Division suggested to General LeMay that ATC take over the air phase of the ECM training program. The next several months saw repeated efforts by SAC, ATC, AMC, and HQ USAF to come to agreement on how to do this, but all efforts were blocked by the lack of a suitable training aircraft. One solution would have been for SAC to loan some RB-29s to ATC, but this was unacceptable to SAC because it

[31]Letter, HQ USAF/Director of Training and Requirements to Commander ATC, 23 May 1949, subj: "Training of Radar Observer, RCM, 7888", in "Development of SAC ECM Program", K416.01; Air Training Command History, Vol 3, pp. 407-408, July-December 1949, 280.01; Letter, Commander 2nd AF to Commander 91st Strategic Recon Wing, 4 March 1950, subj: "ECM Observer Flight Training Program", in "Development of SAC ECM Program", K416.01; all in AFHRA.

would have defeated one of the major reasons for the proposal, namely the need to use those precious aircraft for full-time ELINT operations. The solution ATC favored was to use C-54s, a large four-engine transport which could be modified for training purposes, and AMC was requested to modify six of them. The project suffered from having its work priority frequently lowered, and by the summer of 1950 work on the modification had fallen far behind schedule, thus delaying the transfer of training to ATC. By September, however, work had progressed sufficiently that SAC published Programming Plan 17-50, which transferred the air training phase to ATC effective 26 September. SAC agreed to provide ECM equipment to AMC and to reassign 19 ECM officers to ATC to serve as the instructor cadre. At long last, SAC did not have to worry about the initial training of ECM officers. Finally, it all seemed to be coming together; personnel were being trained, new equipment being developed, and new jet bombers on the production lines (B- 47) or drawing board (B-52). None too soon, given the events in Korea.[32]

[32]Unit Historical Report, 311th Air Division, September-December 1948; SAC Program Plan 17-50, 12 September 1950, subj: "Transfer of Flight Phase of ECM Training to ATC", in "Development of SAC ECM Program", and page 38 of study, K416.01, in AFHRA.

CHAPTER FIVE

ECM IN SAC WAR PLANS: 1948-1950

The ultimate purpose of any weapon system is employment in combat: its effectiveness is determined by the contribution it makes to victory and an improved ability to wage war successfully. The two years preceeding the outbreak of the Korean War saw EW being integrated increasingly into SAC war plans. As SAC improved its ability to mount a strategic air offensive against the USSR and added new aircraft, better trained crews, and more weapons, SAC war planners realized that the growing Soviet electronic capability posed a serious threat to the ability of SAC bombers to penetrate to their targets and safely return. As a result, even as SAC's planners placed increased emphasis on ECM as the best means by which to degrade Soviet air defenses, SAC and the Air Force initiated a large-scale evaluation of tactics, equipment and personnel. The anticipated results would help shape SAC's ECM tactical doctrine, the Air Force's training program, and equipment requirements: in short, nearly everything about Air Force EW.

Soviet Air Defenses

The Soviet occupation of Eastern Europe following the German surrender in May 1945 meant that Russian military authorities immediately obtained access to a wide range of captured German personnel and equipment, including those connected with military electronics and air defenses. Although German flak was still the primary threat to American bombers in early 1945, the Germans were working on a variety of guided surface-to-air missiles (SAMs) when the war ended. The Russians quickly moved to take advantage of the people and equipment they captured, which included several types of anti-aircraft SAMs. It was apparent to American planners that Soviet air defenses would have to depend on radar and electronics, because the country was simply too large to be defended without the speed and range advantages provided by electronics.[1]

Immediately after the war Soviet electronic systems came from two sources. The first, surprisingly, was the United States (and to a lesser extent Great Britain), which had supplied the Soviets with a large amount of high quality radar gear during the war. Eighteen Red Army officers were trained at radar schools in the United States, and nearly fifty SCR-584 radar sets were provided to the Red Army via Lend-Lease. The SCR-584 was an outstanding fire-control radar, and it was widely copied and reproduced in the USSR. Soviet authorities also had copies of another radar, the SCR-527, which was used for ground-controlled intercept (GCI) of fighters and could give good resolution on a bomber at 50,000 feet altitude and at distances up to 115 miles. The Soviets even had a few B-29 bombers which they could copy. These aircraft were not Lend-Lease materiel, however, but aircraft which landed in Siberia after bombing Japan and were then interned by Russia, then still neutral. The Soviets refused to return these aircraft to American control, and thus had access to everything in them, including their radars and other electronics. When the war ended Soviet military authorities had examples of much of the United States' best electronic

[1]"Technical Aspects of USSR Air Defense and Strategic Air Operations Capabilities", pp. A2 through AS, 12 June 1950, 216.191-1, in AFHRA.

equipment.[2]

The second source for Soviet electronics was Germany. Both the people and the equipment captured in 1945 became the basis for the Soviets' postwar electronics program. Within weeks of the German surrender, Russian scientists and technologists had begun work on SAMs and guidance and control systems, using the facilities of the Gesellschaft fur Elektro-akoustische und Mechanische Apparati (GEMA) in Berlin. These efforts continued until 22 October 1946, when the Soviet authorities suddenly and without advance notice evacuated several electronics plants and hundreds of German scientists and their families to deep within the USSR. Many of the highest priority projects included systems critical to air defense: SAMs, gyro-stabilized control systems and electronic computing devices, electronic guidance systems, homing devices, and proximity fuzes. Of these, the development of SAMs would pose the greatest long-term threat to American aircraft.[3]

At the end of the war the Germans had several particularly promising SAMs under development. The *Schmetterling* was the smallest, the *Rheintochter III* was three or four times larger, and the third, the *Wasserfall*, was bigger yet, weighing nearly four tons. These missiles used an optical tracking system and were command

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[2] Ibid, p. A6; Major Bernard Marsden, "A Unified Program for Electronics Countermeasures for Air Defense of the U. S. A.", p. 2, Air Command and Staff School, October 1948, 239.04348, AFHRA.

[3] Asher Lee, "The Soviet Air Debt to Germany", Air University Quarterly Review, Vol V, #2 (Spring 1952), p. 14; Central Intelligence Agency, "A Summary of Soviet Guided Missile Intelligence", 20 July 1953, in Declassified Documents Reference Service (hereafter cited DDRS), #1975 51; Marsden, "A Unified Program for Electronics Countermeasures", p.4.

guided by radio, which made them vulnerable to countermeasures. The following table provides some comparitive details on each missile: [4]

	Schmetterling	Rheintochter III	Wasserfall
Speed	570 mph (.75 mach)	970mph (1.28 mach)	1730mph (2.28 mach)
Weight	950 lbs	3430 lbs	7800 lbs
Warhead	55 lbs	330 lbs	670 lbs
Ceiling (feet)	33,000	48,000	58,000
Range (miles)	13	11	24

The limitations imposed by the Burgund optical tracking system, which seriously affected these missiles' effectiveness in conditions other than clear daylight, could be overcome by radar tracking, although this made them vulnerable to ECM. Ironically, the US SCR-584 radar obtained via Lend-Lease provided an excellent radar tracking capability for possible use with these SAMs. American experts estimated that a missile with the approximate capabilities of the *Schmetterling* could be 50% accurate to within 100 feet against existing propeller-driven bombers at ten miles range and flying at 35,000.[5]

The key word, however, was potential: in the late 1940s all of these missiles were still in the experimental stage, although the USSR was engaged in a major effort to develop its electronics capability. The first step had been the reconstitution of captured German equipment. Next, the Soviets undertook to utilize the German

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[4]"Technical Aspects of USSR Air Defense and Strategic Air Operations Capabilities", p. A15.

[5]CIA, "A Summary of Soviet Guided Missile Intelligence"; "Technical Aspects of USSR Air Defense and Strategic Air Operations Capabilities", p. A56.

scientists they had captured to expand their electronics program. Even after other Germans were repatriated, experts in many air defense and electronics specialties were kept in Russia. As late as 1952, for example, none of the German *Wasserfall* specialists had returned to Germany. By 1954, it was estimated, the Soviets would have an operational air-to-air missile using infrared (IR) or radar homing guidance "reasonably effective against jet bombers under all weather conditions". The implications were obvious: if the Soviet electronics program had been rudimentary in 1945, it was not so limited a decade later.[6]

Planning for a Strategic Air Offensive

Although there is no need to here provide a lengthy and detailed discussion of American war plans during the late 1940s, some mention of how the United States planned to employ strategic airpower against the Soviet Union is necessary to understand the role EW would play in an aerial offensive. Between 1946 and 1950 SAC and the Joint Chiefs of Staff developed at least half a dozen different plans in case of conflict with the USSR; all of them focused on the ability of SAC to carry out a strategic air offensive against the Soviets. The number of plans was almost biblical in its list of "begats": PINCHER begat BROILER, which begat FROLIC, and so forth through TROJAN, OFFTACKLE and DROPSHOT. The details of each are not critical here; what is important to this study is that the size and scope of SAC's strategic bombing campaign constantly increased, from 34 atomic weapons targeted on 24 urban-industrial (U/I) complexes in BROILER (late 1947) to the much larger and

[6] CIA, "A Summary of Soviet Guided Missile Intelligence".

more complex operations planned for DROPSHOT (December 1949). DROPSHOT was in some ways the first of the modern war plans. It assigned approximately 400 atomic weapons against three specific target priorities: those facilities which comprised the Soviet nuclear threat to the US; installations and forces which supported the Soviets' ability to mount a ground offensive into Europe; and those U/I targets which included war-supporting industries such as steel, electric power, and fuel. Following the completion of the atomic attacks SAC was to continue the campaign with a conventional bombing offensive. OFFTACKLE, for example, directed SAC to drop over 17,000 tons of conventional bombs within the first 90 days of hostilities, and by the end of two years of war SAC was supposed to devastate the USSR with nearly a quarter of a million tons of regular high explosives.[7]

The difference between plans and capability is more than spelling, however: one crucial limitation known to relatively few governmental and military leaders was the number of atomic weapons which the United States possessed. Contrary to common belief, the US had only a handful of atomic bombs in its nuclear stockpile. In 1947, for example, it stood at merely a baker's dozen, and by the next year had only increased to fifty. Plans which called for the delivery of several dozen weapons were unrealistic. Worse yet, these early model weapons, most of which weighed nearly five

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[7]Steven T. Ross, American War Plans: 1945-1950, (New York, NY: Garland, 1988), pp 25-128; Kenneth W. Condit, The History of the Joint Chiefs of Staff: The JCS and National Policy, Volume II, 1947-1949, Historical Division, Joint Secretariat, JCS, (Washington, DC: GPO, 1978), pp. 280-291; Anthony Cave Brown, DROPSHOT: The United States Plan for War with the Soviet Union in 1957, (New York, NY: Dial Press, 1978), pp. 201-202.

tons and had a yield of about 20 kilotons (KT), required a 39-man team two days to assemble, and even then could only be held in readiness for 48 hours, after which the batteries needed recharging. By January 1949 there were only seven of these teams. Clearly, the goal of a massive atomic counterstroke in the event of Soviet aggression was unreachable.[8]

Even if sufficient weapons had been available, however, SAC simply did not have enough bombers with which to do the job. In 1946 only the B-29s of the 509th Bomb Group, which had undergone the wartime "Silverplate" modification to enlarge the bomb bay to accomodate the bulky atomic bomb, could actually carry and drop the new weapon. In December 1947 the Air Force had only 33 of these modified bombers, although the force was growing. By 1949, the JCS noted, SAC would have about 120 bombers capable of delivering atomic weapons, and by 1950 the number would grow to over 200: 95 older B-29s from World War II; 98 of its upgraded clone the B-50; and 34 of the new and controversial B-36. This force of 227 aircraft met, but just barely, the JCS requirement for 225 atomic-capable aircraft as of 1 January 1950. To further improve its overall combat capability the Air Force initiated a project called "Global Electronic Movement" (GEM), which would not only increase the number of atomic-capable bombers but would also modify some into aerial tankers. Additionally, GEM would upgrade the electronics of the bomber force and equip a small number to provide electronic protection to the rest of the bomber force.

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[8]Borowski, "Air Force Atomic Capability from VJ-Day to the Berlin Blockade--Potential or Real?", p. 108; Ross, American War Plans, p. 12.

Yet none of these improvements could overcome the effect of the critical logistical difficulties SAC faced. In mid-1949 the only bomber which SAC could deploy overseas rapidly was the B-29, its least capable airplane. For at least the first six months of a war it would be the only bomber SAC could operate from overseas bases, and although SAC could complete the atomic phase of the aerial offensive, the complete plan, including the prolonged conventional attack, was for the time being out of reach.[9]

SAC also took steps to improve its training and operational procedures. Prior to the time when General LeMay took command, SAC had used the World War II-era system of not assigning a target to a crew until just before the start of the mission. LeMay changed this. Since the war plan contained the complete target list, SAC began to assign a particular target to each individual crew on a semi-permanent basis. This enabled each crew to study its target in detail and to train accordingly. For example, if the target was alongside a lake or river the crew would fly training missions against similar terrain, and the Combat Plans division prepared radar scope illustrations of how the target should look on the radar screen. The intent was for each crew to be as familiar with its target as possible before it might have to attack in

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[9]Ibid., pp. 12-13; Memo, Air Force DCS/Operations, Assistant for Atomic Energy, to Major General Schlatter, 13 January 1950, Subject: "Air Force Capability for Atomic Warfare", in DDRS, #1978 151A; Air Material Command History for 1948, p. 64, 200-8 in AFHRA; Wilson, "Air Policy Commission", pp. 270-272; Memo, Air Force DCS/Material, Assistant for Logistics Plans, to DCS/Operations, Director of Plans and Operations, 7 April 1949, Subject: "USAF Capability in the Advent of War in the Immediate Future", and Memo, Air Force DCS/Operations, Director of Plans and Operations, to Secretary of the Air Force, 11 April 1950, Subject: "USAF Capabilities in Event of War in 1950", both in DDRS #1978 242A and 242B.

combat. This form of realistic training was one of LeMay's most important contributions to SAC: decades later, realistic, combat-oriented training remained a hallmark of SAC. As will be discussed later, this training extended to EW as well.[10]

EW in the War Plan

Electronic Warfare was not excluded from the war plans: in fact, it was central to them. One of the ECM officers at SAC during this period, Captain Frank Witry, has stated that nearly half of the actual strike plan was devoted to ECM. Each bomber would carry those jammers most effective against the radars they would probably encounter, and each crew was instructed on which frequencies to jam and when to drop chaff. Witry gave the credit for this to Colonel (later General) Joe Bestic, SAC Director of Communications-Electronics and a strong advocate of EW, although several other members of the SAC staff, mentioned earlier, were also avid proponents of Electronic Warfare. Bestic, for example, credited General Montgomery, SAC DCS/Operations during the late 1940s, with giving strong support to the development of ECM for SAC and for seeing the need for ECM in the war plans.[11]

Electronic Warfare was becoming so important that SAC was developing a doctrine for ECM operations in combat, and by 1950 it had become an indispensible part of the strike plan. A 1948 draft "Doctrine of Atomic Air Warfare" noted that

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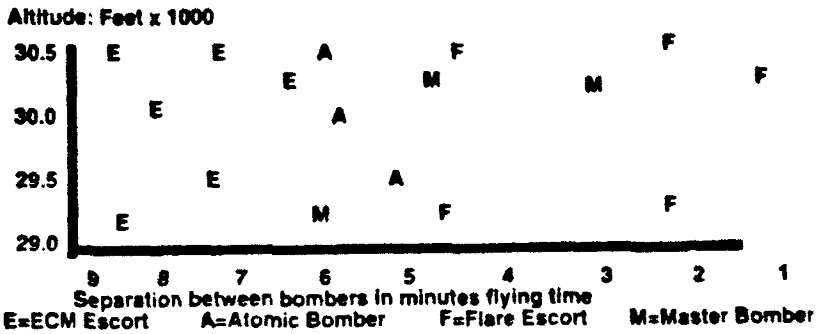
[10]Borowski, A Hollow Threat, p. 168; Borowski, "Air Force Atomic Capability from VJ-Day to the Berlin Blockade--Potential or Real?", p. 109; Ross, American War Plans, pp. 12-13.

[11]Transcript of Interview with Frank Witry, AOC Archives; Roster of Officers at HQ SAC, 1 December 1949, K416.271; USAF Oral History Program Interview with Major General Joseph Bestic (Ret.), K239.0511-6, both in AFHRA.

"losses can be greatly reduced by the use of ECM", and it offered a sample bomber formation, designed to offer maximum self-protection and ECM effectiveness.

Figure 5
Bomber Cell Formation



An individual bomber formation of about 16 airplanes would be ideal: it could provide ECM and gunnery escorts, an airborne "master bomber", and several atomic bomb carriers. Each striking group would thus have ECM escorts equipped with a variety of jamming capabilities. Formation leaders would also have jammers for early warning and gun-laying radars, while others would be concentrated on jamming GCI radars and fighter-controller links for voice communication. Aircraft carrying atomic weapons would carry only a limited amount of ECM equipment, primarily for jamming searchlight and AAA radars.[12]

The idea of using ECM escorts in the strike force was not, however, just a concept in a draft document: it was already a part of the actual strike plan. The 1948

[12]USAF Field Office for Atomic Energy, Draft, "Doctrine of Atomic Air Warfare", 30 December 1948, in DDRS, #1978 150B.

operations plan called for up to four ECM escorts for each atomic bomb carrier. The TROJAN plan, for example, would require eleven bomber groups to carry out the primary mission of destroying the Soviets' ability to assemble and deliver atomic weapons. These eleven groups would deliver between 75 and 100 atomic bombs on Soviet targets, and each bomb carrier would be accompanied by four escorts to provide ECM and defensive support. A 1948 memo by the Operations Analysis Division on the potential aircraft requirements for a future strategic atomic bombing campaign indicated that ECM escorts were essential if aircraft losses were to be kept to a minimum. According to this memo, the greatest danger to the strike force was posed by Soviet night fighters, which would place a premium on the bombers' ECM capability against Soviet GCI radars and their fighter control system.[13]

The precise details of the war plans of the late 1940s and how EW fit into them remain highly classified.[14] Perhaps the best available source is a study submitted to the JCS in early 1950 by the Weapon System Evaluation Group (WSEG), "Report on Evaluation of Effectiveness of Strategic Air Operations", sometimes called the Hull Report after the study leader, Lieutenant General J.E. Hull (US Army). The focus of

[13]Brown, DROPSHOT, p. 201; Letter, Air Force DCS/Operations, Assistant for Atomic Energy, to Air Force DCS/Operations, Assistant for Programming, 3 November 1948, Subject: "ECM Equipment", in "Development of SAC ECM Program"; Memo, Air Force DCS/Operations, Director of Training and Requirements, to SAC Operations Analysis Division, Subject: "Aircraft Requirements for a Strategic Atomic Bombing Campaign Against the USSR in 1952 Using Aerial Refueling", March 1948, in DDRS #1977 241C.

[14]That is, they were as of the researching and writing of this study; it may well be that the tremendous changes in the world order, especially the collapse of the Soviet Union, could lead to a greater opening of these records.

the report was a wargame involving attacks by large SAC bomber formations against Soviet targets in the Black Sea region. Several iterations of the game were played, against varying levels of Soviet air defense effectiveness. Not surprisingly, the study concluded that attacks at night suffered the lowest losses, but this was scant consolation, for wargame loss rates ranged from approximately 30% to over 50%. Soviet defensive forces included current (1950) radars, jet and piston engine fighters, and AAA, but did not include any SAMs, while SAC was assumed to have only those ECM devices current in 1950.[15]

The statistical results of the wargames are of less importance than those aspects relating to the EW role in the strike plan. Based on current SAC operational doctrine, the wargame included large numbers of ECM aircraft whose mission was to divert Soviet air defenses from the aircraft carrying atomic bombs. In most cases each bomb carrier had two or more similar aircraft acting as ECM escorts. The report noted that while American ELINT capabilities were limited to the perimeter of the USSR, most targets were located far within Soviet borders, which prevented gaining any substantial intelligence about what electronic defenses protected any particular target. This gave added impetus to the requirement to develop better ELINT gathering capabilities. The report also noted that improvements in ECM capabilities could lead to "great advances" in the ability of the strike force to protect itself and reduce losses. The

[15]Brown, DROPSHOT, pp. 24-26; Condit, History of the JCS: Volume II, 1947-1949, pp. 343-344; Office of the Secretary of Defense, Weapon Systems Evaluation Group, "Report on Evaluation of Effectiveness of Strategic Air Operations" (JCS 1952/11, hereafter cited as "Hull Report"), 8 February 1950, in DDRS #1976 159A.

problem, however, was that current (1950) SAC ECM capabilities, which were still essentially based on World War II-era equipment, would not reduce the probability of successful interception by Soviet fighters, even at night. Clearly, one of the Air Force's most pressing needs remained the development and deployment of modern EW equipment.[16]

As SAC increasingly relied on ECM as its primary means of bomber self-defense it sought for ways to make its ECM tactical doctrine more effective. In the summer of 1949 the 2nd Bomb Group initiated a series of ECM practice missions and equipment tests. These tests, which were not completed until that November, were designed to test the effectiveness of ECM tactics and equipment including chaff against GCI and gun-laying radars, fighter control communications, and early warning radars. Flown against the radar system at Eglin AFB, Florida (site of the Air Proving Ground) and against Biggs AFB, El Paso, Texas, the 2nd Bomb Group performed day and night penetration missions at high (35,000 feet) and low (500 to 1,000 feet) altitudes. Each mission normally scheduled three B-50s from each of the group's three squadrons, but mechanical problems often kept one or two aircraft from launching. Mechanical difficulties frequently affected the ECM equipment too, as jammers failed to function and chaff dispensers clogged, even though equipment "in commission" rates were higher than average. The tests did, however, present an

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[16]"Hull Report".

interesting and useful picture of SAC's overall ECM capability in 1949.[17]

One clearcut finding was that chaff was the most effective ECM device SAC possessed. Random chaff drops were more effective than when chaff was dropped continuously. Even sporadic emissions resulted in sufficient degradation of the overall radar picture to insure that defenses were unable to guage accurately the distances, timing and tactics of the attacking bomber force. An observer from the 2nd Bomb Wing (the 2nd Bomb Group's parent unit) suggested that the leading aircraft in any bomber formation should be an ECM carrier to screen those aircraft carrying bombs. Using a combination of random chaff drops, evasive action, and changes in altitude throughout the formation, the bomber force could approach the target well obscured from defenses. These findings were similar to the experiences of other SAC units, the 98th and 509th Bomb Groups, which were on rotational duty in Great Britain. Despite having to use trainee radio operators to operate the ECM equipment, their jamming efforts against Royal Air Force fighters were so effective that the fighters were unable to make any successful interceptions.[18]

ECM Tactical Evaluation

The 2nd Bomb Group's ECM tests during 1949 were evidently sufficiently useful to spark a larger and more inclusive effort to test equipment, personnel and doctrine. In January 1950 the Air Force Chief of Staff verbally approved a SAC proposal to

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[17]8th Air Force History, Volume I, pp.164-165 and tabs 75 & 76, May-August 1949, and September-December 1949, Volume I, pp. 150-155, 520.01, AFHRA.

[18]Ibid.; 98th Bomb Group unit historical report, 28 May-29 August 1949, AFHRA.

earmark one of its units for a test program to develop ECM tactics and techniques. The next month HQ USAF formally approved this project, called the "Tactical Evaluation of Electronic Countermeasures", to be held at the Air Proving Ground Command (APGC). The program was a wide-ranging effort that involved several of the Air Force's major commands, including SAC, Air Materiel Command, APGC, and Continental Air Command (which was shortly to be split into the Tactical Air Command, or TAC, and Air Defense Command, or ADC). Its ambitious mission: "evaluate all phases of electronic countermeasures as pertains to the entire Air Force."[19]

Given the 2nd Bomb Group's experiences of the previous year, it was not surprising that one of that unit's components, the 20th Bomb Squadron, was designated as the primary test vehicle for the project, and in April SAC established some of the test parameters. A wide variety of ECM equipment would be evaluated, including receivers, transmitters and chaff. Each piece of equipment would be tested twice: once when operated by an enlisted radio operator who had been trained to accomplish spot jamming operations, and once by an officer Radar Observer/ECM, SSN 7888. Since the Radar Observer/ECM was considered to be an expert in the operation and maintenance of ECM equipment, this would establish a benchmark against which the performance of the radio operators could be measured, a useful testing technique. Some of the specific capabilities to be tested included jamming of

[19]SAC Programming Plan 12-50, 28 August 1950, Subject: "Tactical Evaluation of Electronic Countermeasures", in "Development of SAC ECM Program", AFHRA.

command-control systems for missile guidance and the suitability of the standard A-1 chaff dispenser for random chaff dispensing. SAC wished to develop the best tactics and techniques for penetrating early warning (EW) and GCI radars and for jamming fire control radars, so the testing area would require an EW-GCI radar belt 300 miles deep, as well as HF-VHF fighter control facilities with actual fighters which could be used to evaluate the jamming effectiveness, and an AAA defense system with fire-control radars in the 450-600 MHz and 2700-3300 MHz frequency bands. The test document recognized that it would be impossible to carry sufficient jamming gear to counter all electronic systems which the bomber force might encounter, so one of the objects of the test was to determine what links in each radar system were the most vulnerable and what ECM tactic would prove most effective in shielding the bomber force. The methodology to be followed was to fly early test formations during the day, to mitigate navigation and aircraft control problems. Once the optimium tactic was developed it would then be tested at night, to determine how it could be used under night or bad weather conditions.[20]

The SAC program plan which stated the overall test objectives demonstrated the crucial change in attitude towards EW which had taken place within SAC. Noting that since World War II "ECM has remained a static art", in contrast to aircraft, armament and radar, SAC officials felt that the continuing "trial and error" approach to ECM equipment development and tactical evolution needed to be changed. SAC leaders

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[20]Letter, SAC DCS/Operations to Commander 2nd Air Force, 27 April 1950, Subject: "Project 7502-5", in "Development of SAC ECM Program", AFHRA.

now realized that the critical next step was the systematic test and evaluation of each component of what they now called "electronic countermeasures weapons systems". These, they had finally come to see, must be conducted in carefully controlled tactical simulations designed to see how the various parts interacted. Even calling the ECM equipment to be tested "weapons systems" was significant and marked a realization that ECM was a weapon and not simply accessory equipment.[21]

Program Plan 12-50 listed five specific objectives for the testing project. The first, as described above, was to test the performance and suitability of existing and future ECM equipment, while the second focused on tactics and techniques. SAC also wished to determine future ECM requirements, because a coherent R&D program could not be developed until requirements, defined in terms of actual capabilities, were established and formalized. The development of standard operating procedures for employment was also an objective, while the fifth and final one was to establish training standards for ECM operators. All tests would be accomplished in phases. First would be the basic evaluation of equipment capabilities and operator performance, followed by an examination of tactics, first for individual pieces of equipment, then for equipment in combination. Finally, the test would take a weapons systems approach, evaluating equipment, personnel and tactical doctrine all together, to determine their overall effectiveness.[22]

The 20th Bomb Squadron (BSq) began its activities by assembling all available

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[21]SAC Programming Plan 12-50.

[22]Ibid.

ECM equipment (some of it recalled from depot storage), checking it for servicability, proof testing it in flight, and training the squadron's combat crews in its use. The fact that the testing unit needed to accomplish all this before starting the test tells a great deal about the neglected status of the Air Force EW program in 1950. The 20th Bomb Squadron had just requipped with the B-50D, however, and this accounted for at least some of the delay. The first flight tests took place on 19 June 1950, less than a week before the outbreak of the Korean War, and emphasized current SAC equipment (five different jamming transmitters and chaff) and tactics. Early tests indicated that even with the existing outmoded equipment, successful jamming of GCI radars and fighter control links was a "definite possibility". The most effective ECM device, however, remained chaff, which the 2nd Bomb Wing (the 20th BSq's parent unit) felt represented 80% of the wing's ECM capability.[23]

One difficulty adversely impacting the testing schedule was the shortage of ECM officers at Air Proving Ground Command (APGC), which had only three officers assigned to the project. One of them, in fact, had just been recalled to active duty and had to refamiliarize himself with the ECM program. This problem was addressed at a conference held at APGC on 28 September 1950. The Air Force was anxious to accelerate the ECM testing program, probably because of the recent outbreak of hostilities in Korea and fears that it was only a precurser to a larger, more involved struggle in Europe. The 20th Bomb Squadron could increase its participation, but

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[23]Letter, 2nd AF Chief of Staff to Commander SAC, 29 July 1950, Subject: "ECM Evaluation Program, APGC Project 7502-5", in "Development of SAC ECM Program"; 2nd Air Force History, Volume I, pp. 105-106, July-December 1950, K432.01, AFHRA.

personnel and equipment shortages at APGC had slowed the pace of the tests so that only one test at a time could be conducted. This was an artificial limitation, because flight testing of several pieces of equipment including chaff could run simultaneously if sufficient personnel, especially electronics officers, were provided. The commander of the 2nd Bomb Wing suggested that SAC and Continental Air Command send some ECM officers on temporary duty (TDY) to APGC to facilitiate speeding up the tests. He also wished to see testing of current ECM tactics begun "at the earliest date possible", and for information from engineering and tactical tests to be included in the exploration of tactical doctrines for ECM on a real-time basis, so that it would evolve along with the course of the tests.[24]

This course of action was given powerful support in December, following a visit to HQ SAC by members of the APGC test team. General LeMay wrote to APGC commander Major General Bryant Boatner, "I am convinced that we should keep the test program going full-out... taking on the spot whatever action appears appropriate." General LeMay was convinced the test program offered potentially significant tactical benefits, but it also had, he believed, "a long way to go". His concern was highlighted by the priority HQ USAF assigned to the ECM test program: Priority 1A, Precedence 1, Group 1, supply priority S1. The collection of "ones" indicates how important it

[24]Letter, Deputy Commander 2nd Bomb Wing, through Commander 2nd AF, to Commander SAC, 6 October 1950, Subject: "ECM Test Program", in "Development of SAC ECM Program", AFHRA.

was![25]

By the start of 1951 the testing program was moving along quite rapidly. Although it would be far too detailed and time-consuming to examine every test, the two major operations conducted in early 1951 provide a highly illustrative picture of how they were conducted and of SAC's ECM capability. On the night of 4 January 1951 the 2nd Bomb Wing scheduled 14 B-50D bombers (10 were primary test aircraft, while the other 4 were airborne spares) to carry out a test against EW, GCI and gun-laying radars. They were to fly at 26,000 feet from their base near Savannah, Georgia, to Abilene, Texas, then form into the ECM cell formation called for by the SAC tactical doctrine. The bomb carriers were placed behind the support aircraft (ECM escorts), with a vertical separation of 400 feet between aircraft. From Abilene they proceeded to the target at Eglin AFB, Florida. When they got within 200 miles of the target they would begin jamming and random chaff dropping, and when they were five minutes from the target begin continuous chaff dropping until the supply was exhausted. From 30 miles before the target until 30 miles after the primary jamming effort would be against gun-laying radars in the S Band.[26]

Although 14 aircraft were scheduled to launch, the actual course of events fell

[25]Letter, General Curtis E. LeMay, Commander SAC, to Major General Bryant Boatner, Commander APGC, 9 December 1950; and Letter, Deputy Commander APGC, through Commander SAC, Commander ADC, and Air Force Director of Research and Development, to Air Force Director of Requirements, 9 April 1951, Subject: "Allocation of Aircraft for Electronic Instrumentation"; both in "Development of SAC ECM Program", AFHRA.

[26]2nd Bomb Wing unit historical report, January 1951, and Exhibit 3, Mission Report for Mission of 4 January 1951, AFHRA.

well short of the plan, and the difficulties encountered on this mission reveal a great deal about the condition of the SAC strike force in 1951. Two aircraft aborted before takeoff and never made it off the ground, and four more fell out along the way due to various mechanical difficulties, so only eight of the scheduled fourteen B-50s attacked the target. Even worse, of the five ECM officers and five trained radio-ECM operators scheduled to fly the mission, only four actually made it to the target: three each of the ECM officers and radio-ECM operators were aboard the aircraft which aborted, which meant that they were replaced by four semi-trained and inexperienced radio-ECM operators on the spares. This obviously had a negative impact on the overall ECM capability of the formation. Additionally, equipment malfunctions further degraded the formation's ECM capability: of the six ECM aborts two were due to problems with the actual ECM equipment. As a result, the formation entered the target area with only 50% of its potential chaff capability operational, and only 40% of its electronic jamming capability. Some of these failures were due to the age of the equipment, which was all of World War II vintage, and some were due to personnel shortcomings, both among the operators and the maintenance staff. The key point is that these events occured in a formation of B-50s, SAC's primary strike aircraft, and in a unit conducting special tests and not just doing the daily training grind at a typical base. There is absolutely no reason to assume that if this had been a combat formation penetrating Soviet airspace the results would have been any better: very likely they would have been much worse.[27]

[27]Ibid.

The results obtained from this mission reflect the difficulties which it encountered. When the time came to begin jamming only four aircraft could jam EW and GCI radars operating in the L Band, and of these only one aircraft intercepted a signal and attempted to jam it until the formation was within 30 miles of the target, at which time several more signals were detected and jammed. The same was true for GCI and gun-laying radars in the S Band. For HF and VHF fighter control communications in the F and H Bands the story was quite similar, and a few attempts were made to jam HF and VHF signals. Seven aircraft began random chaff drops at the 200 mile point. One experienced a jammed chaff chute after only two units of chaff were dispensed; of the remaining six, random drops continued until 30 miles before the target, when they switched to continuous chaff dropping. Of those six, two suffered malfunctions within two minutes.[28]

For purposes of comparison it will be useful to skip past several additional tests to the mission of 7 March 1951, for which the 2nd Bomb Wing (augmented by the 93th Bomb Wing) scheduled 15 primary and 7 spare B-50s to fly another ECM test mission against the Eglin AFB complex. The purpose of this mission was to investigate tactics for jamming GCI and gun-laying radars, fighter control channels, and chaff dispensing methods. The formation used this time showed a tactical sophistication not present two months earlier. The bombers were divided into three cells of five primary aircraft and two or three spares each and directed to pass the target so as to provide the maximum diversionary support. Eight of the primary

[28]Ibid.

aircraft carried ECM officers, while the other seven had radio-ECM operators. The aircraft were equipped with the same type of receivers and adaptors, but had two different types of chaff and four types of transmitters.[29]

Unfortunately, this mission experienced some of the same mechanical troubles as the 2nd Bomb Wing had experienced in the past. Cell Able suffered the loss of one spare to a ground abort and the loss of a primary and another spare en route to the target. Cell Baker had a primary aircraft abort because it lost an engine, while Cell Charlie (from the 93rd Bomb Wing) lost a primary and a spare to airborne aborts. Out of 22 aircraft scheduled, therefore, the mission lost 6 to mechanical failures, although none concerned the ECM systems. All but one of the bombers attempted to jam fighter control frequencies (it had a transmitter failure), while two of them attempted HF jamming. The key position for the aircraft was a point tangent to a circle 16 miles out from the target: five minutes before reaching that point all aircraft were to start jamming GCI and EW radars in the S and L Bands. At the same time they were to start rapid dispensing of chaff until it was exhausted. Eventually seven aircraft attempted to jam on the S Band, while six jammed the L Band. The chaff exercise was extremely ragged: while five aircraft completed 100% of the drop, six completed 10% or less, due to equipment problems.[30]

The exercise encountered several serious problems, some of them old, some quite

[29]2nd Bomb Wing unit historical report, March 1951, and Exhibit 2, Mission Summary Report for Mission of 7 March 1951, AFHRA.

[30]Ibid.

new. The mechanical difficulties which the bombers suffered were an old song, as was the unreliability of the A-1 chaff dispenser with which the 93rd Bomb Wing's B-50s were equipped: every one of them failed, mostly because the chaff was jamming inside the dispenser. Another problem was simple equipment shortages: only 8 of the 15 aircraft were equipped with effective panoramic adaptors; since these indicated the radar frequency being received spot jamming was impossible without them. Most serious was the lack of electrical filters in the jamming transmitters: when they were placed in operation electronic feedback rendered the search receivers unusable. This, in the opinion of the summary report, was the greatest single factor detrimental to the success of the ECM phase of the mission.[31]

A few days after the summary mission report was forwarded to HQ 2nd Air Force, the commander of the 2nd Bomb Wing, General Glantzberg, made his own assessment of the situation, and it was not a good one. The ECM equipment with which SAC units were equipped, the equipment that had been used in the tests, simply could not do the job required by the SAC tactical doctrine. Despite intensive maintenance the equipment proved to be inadequate and unreliable, which degraded its already limited jamming capability. Additionally, the navigational precision required of the ECM cell by the tactical doctrine had proved to be virtually unattainable. As a result, some ECM efforts, such as chaff dispensing, could actually help night fighters locate the bombers. General Glantzberg suggested that tests of the current tactical doctrine be suspended until the procurement of new and better ECM equipment.

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[31]Ibid.

although he felt that the 2nd Bomb Wing should continue its effort to develop new tactics and procedures. In essence, he was saying, there was a limit to what could be accomplished with out-of- date, World War II-era ECM equipment, and that limit had been passed.[32]

The ECM tactical evaluation evolved into a continuing effort to develop new ECM equipment and tactics. That story, however, will be discussed later. By early 1951 it was apparent that EW had been reborn, even though it still had a lot of growing to do. Because of SAC's realization that EW would be critical to its capacity to penetrate Soviet defenses successfully, the role which ECM had in the SAC tactical doctrine and the atomic strike plan was soon to receive the highest priority. Even while the ECM tactical evaluation was taking place, however, an evaluation of an entirely different sort was taking place half a world away. While test missions were being flown by B-50s over Florida, B-29s were flying combat missions over Korea. The Air Force was at war again, and again ECM would have to prove itself in combat.

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[32]Letter, Commander 2nd Bomb Wing to Commander 2nd AF, 19 March 1951, cited and paraphrased in 2nd Bomb Wing unit historical report, March 1951.

CHAPTER SIX

REFIGHTING THE LAST WAR: KOREA, 1950-53

Just about the last thing the USAF expected in mid-1950 was a conventional war in Korea. It was all wrong, at least doctrinally: no direct Russian involvement, no nuclear weapons, and lots of interdiction and close air support. As a result of the Air Force decision that the development of SAC's jet bomber force would continue to have priority, SAC forces sent to Asia were rather modest. Throughout the war, Far East Air Forces Bomber Command (FEAF/BC) had to rely on no more than 100 aging B-29 "Superforts", flown largely by recalled reservists and equipped with World War II-era electronics. Although both the Americans and the Soviets were unwilling to reveal too much of their most advanced combat capabilities, they did treat the war as a form of combat laboratory, testing equipment, tactics, and personnel. This was also true of Electronic Warfare, and the Air Force spent most of the war relearning old lessons about ECM.

Phase One: Daylight Operations

Although the Air Force was certainly surprised by the outbreak of the Korean War, it reacted quickly. In June 1950 Air Force bomber strength in the Pacific was quite limited, with only the 22 B-29s of the 19th Bomb Group immediately available. General George Stratemeyer, Commander of FEAF, quickly shifted them to Okinawa, thousands of miles closer to the combat area. At the same time, the JCS approved sending two additional groups of B-29s to FEAF, and on 8 July 1950 FEAF Bomber Command was formed, under the command of an experienced bomber leader, Major General Emmett "Rosie", O'Donnell. Although these two units had little atomic capability, because of their low priority in the ongoing SAC conversion program, they did have the ability to conduct conventional bombing operations. Displaying tremendous flexibility, within a week of the decision to send them to the Far East they were engaged in combat. By the end of July 1950 these two units, the 22nd and 92nd Bomb Groups, were augmented by two additional units, the 98th and 307th Bomb Groups. As the ground situation reached crisis proportions, FEAF/BC operated in support of a two-fold mission: interdiction of North Korean lines of communication, and destruction of war-related North Korean industry.[1]

The campaign to eliminate the North Korean industrial system began on 30 July 1950, and within three months there were practically no strategic targets left standing. At this stage of the war the bombers had it easy. As the commander of the 22nd Bomb Group said, "Our bombing should have been good...we didn't have any opposition."[2] Operating at approximately 15,000 feet against no fighter and minimal anti-aircraft defenses, the B-29s systematically wrecked nearly every significant industrial installation in North Korea. By late 1950 the bombers

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[1]John Pimlott, B-29 Superfortress, (Englewood Cliffs, NJ: Prentice Hall, 1983), p.52; James F. Schnabel and Robert W. Watson, The History of the Joint Chiefs of Staff, Volume III: the JCS and National Policy, the Korean War, Part I, JCS Joint Secretariat, Historical Division, (Washington DC: GPO, 1978), p. 179; Robert F. Futrell, The United States Air Force in Korea: 1950-53, (Washington, DC: Office of Air Force History and GPO, 1983), (hereafter referred to as USAF in Korea,) pp. 45-46, 87, 179; Far East Air Forces Bomber Command, "Heavyweights Over Korea", AUQR, III, #1 (Summer 1954), pp. 99-100: Curtis E. LeMay, with MacKinley Kantor, Mission with LeMay, (New York, NY: Doubleday, 1965), p. 485.

[2]Futrell, USAF in Korea, p. 185.

practically ran out of targets, as the impact of General MacArthur's advance and the JCS-imposed prohibition on operations across the Yalu River took effect. The 22nd and 92nd Bomb Groups were even returned to the United States in October, as the Air Force looked towards an end to hostilities. But the Chinese intervention in late November changed all that: the massive human resources of the Chinese, and the military aid being supplied by the Soviets, clearly made a long conflict more likely. There would probably now be increased opposition to USAF operations, and indeed, as the B-29s operated closer to the Yalu they encountered increased AAA and began to sight the first MIG-15 jet fighters. In November 1950 an RB-29 was shot down near the Yalu, and it was apparent that now the old bombers would have to fight.[3]

The destruction of the fledgling North Korean Air Force early in the war placed the Soviets on the horns of a dilemma: if they were not to totally abandon the North Koreans they would have to either fly and fight themselves, or else supply the Chinese with massive amounts of aerial aid. They chose to build up the Chinese Air Force (CAF), and provided several forms of aid. Probably the most visible form was aircraft: by mid-1951 the CAF had over 400 modern MIG-15 jet fighters, based at Soviet- constructed bases along the north side of the Yalu in Manchuria. The Soviets also supplied large amounts of AAA, including many of the fine 76mm and 85mm guns which posed a threat to the B-29s, although few of the North Koreans' guns were at this time radar-controlled. By 1951 the North Korean AAA system had

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[3]FEAF/BC, "Heavyweights Over Korea", p. 104; Futrell, USAF in Korea, p. 216; Robert A. Jackson, Air War Over Korea, (New York, NY: Scribners, 1973), p. 65.

grown considerably, especially around targets like Pyongyang, the capital. During the early stages of the war most of the radar in use by the North Koreans was of Japanese origin, gear which had been captured after World War II.[4]

The Chinese fighters were based at modern installations in Manchuria that not only had concrete runways but also the advantages of being linked electronically to an efficient early warning radar net, which included installations at Vladivostok, Antung and Pyongyang. They also enjoyed the advantages of at least three ground controlled intercept (GCI) radars placed along the Yalu, from where they could effectively guide interceptors into contact with American aircraft. By 1950 the Soviets had deployed an early warning radar network along the country's borders, using radars based on the equipment which they had captured from the Germans, primarily the "Freya" for early warning and the "Wurzburg" for searchlight and AAA control. Newer, more modern equipment was in development, however, and the Soviets would use Korea as a training and testing ground, much as they did the Spanish Civil War in the 1930s. Although the United States entered the Korean War with a bit of a superiority complex regarding the supposedly inferior state of Soviet technology, the appearance of advanced radars and aircraft, especially the MIG-15,

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[4]Kenneth R. Whiting, Soviet Air Power, (Boulder, CO: Westview Press, 1986), p. 38; Joseph. E. Thach, "Soviet Military Assistance to the PRC, 1950-60", Military Review, LVIII, #1 (January 1978), pp. 72-73; Richard P. Hallion, The Naval Air War in Korea, (Baltimore, MD: Nautical and Aviation Publishing Co of America, 1986), p. 107; Andrew T. Soltys, "Enemy Anti-Aircraft Defenses in North Korea", AUQR. VII, #1 (Spring 1954), pp. 75-76; Transcript of interview with Ingwald Haugen, AOC archives, Alexandria VA.

would give Americans cause to regret their technological hubris.[5]

It was fortunate for the B-29s that they did not need ECM early in the war, for at first their capability to conduct EW operations was almost nonexistent. A postwar report by FEAF/BC on the use of ECM outlined some of the specific deficiencies, many of which should have been corrected during the intervening half-decade between the end of World War II and the start of hostilities in Korea. On most crews the radio operator doubled as the ECM operator, yet the two sets of equipment which he was expected to operate were at opposite ends of the tunnel separating the B-29's two pressurized compartments. This was not a serious problem during World War II, since most B-29s conducted only barrage jamming and thus did not need an ECM operator to constantly monitor the equipment, but the limited number of bombers available in Korea meant that only spot jamming would be effective, and that needed a full-time operator. Even the ECM operator's position was unsatisfactory: his seat was the lid of the chemical toilet, and the position lacked seat belts, oxygen outlet, lights, even an intercom. Most units in the Far East had less than 50% of their radio operators trained for or experienced in ECM operations. To

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[5]Asher Lee, The Soviet Air and Rocket Forces, (New York, NY: Praeger, 1959), p. 121; Soltys, "Enemy Anti-Aircraft Defenses Over North Korea", p. 75; Whiting, Soviet Air Power, pp. 78, 128; Richard E. Stockwell, Soviet Air Power, (New York, NY: Pagent Press, 1956), pp. 54-56; Richard M. Bueschel, Communist Chinese Air Power, (New York, NY: Praeger, 1968), pp. 21- 23; Haugen transcript, AOC archives; Far East Air Forces Bomber Command, "History of Electronic Countermeasures During the Korean Conflict, June 1950 to July 1953" (hereafter referred to as FEAF ECM Study), Annex VII, "Electronics Intercept Summary, Week Ending 14 July 1951", 3 May 1954, K720.04C, in AFHRA.

cap it all, the six month tour of duty in FEAF meant that just as a crewmember reached a point where he could really benefit from his combat experience, he rotated back to the United States. By using Korea as a training ground, SAC did expose more personnel to combat operations, but this experience resulted in the need for nearly constant training of newly-arrived personnel.[6]

Even if none of these shortcomings had existed, however, others would have hampered the conduct of ECM operations. None of the B-29 units possessed a full complement of ECM requipment, and what they did have was both unevenly distributed among the units and of limited effectiveness. Nearly all of it was of World War II vintage and very inadequate for spot jamming operations. Not until mid-summer 1951 were most of the B-29s equipped for spot jamming. Despite the limited capability of the equipment, however, it was sufficient against the gear which the North Koreans had in operation at that time. Even so, lessons of the recent past needed to be relearned. That the climate on Okinawa could cause problems for electronic equipment should have come as no surprise after five years of occupation, but at least one unit, when it returned to the US in November 1950, found that 50% of its ECM equipment had fallen victim to fungus and corrosion.[7]

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[6]FEAF ECM Study, pp. 1-2; Richard G. Hubler, SAC: the Strategic Air Command, (New York, NY: Duell, Sloan and Pearce, 1958), p. 102; Robert L. French, "Criteria of B-29 Crew Performance in Far Eastern Combat", Human Resources Research Center, Air Research and Development Command, (Randolph AFB, TX: October 1953), pp. iii, 4.

[7]FEAF ECM Study, pp. 2-3 and Annex III, "ECM Summary, 1 June 1951"; Unit History, 98th Bomb Group, May 1951, AFHRA.

A second problem area was ELINT: when the war broke out FEAF had only the 31st Strategic Reconnaissance Squadron (SRSq) available for intelligence gathering beyond the immediate battlefield. In November 1950, during the critical period of the Chinese intervention, it had nine photo and two ELINT-configured RB-29s on hand. In early 1951 the situation deteriorated further when the 91st SRSq (the 31st had been redesignated) lost one of the two ELINT aircraft to salvage. As a result, the bombers had to do much of their own ELINT, and in March 1951 Bomber Command even published a directive outlining how the bombers' electronic search operations would be conducted and reported. Organizational and administrative limitations also hampered the ELINT operation. Although FEAF would start receiving newer RB-50s in late 1951, the lack of an element dedicated to processing electronic intelligence delayed the evaluation of the raw data. Furthermore, the very high classification of this critical data sometimes prevented it from reaching the enlisted radio/ECM operators, thus keeping it from the men who actually needed to use it in combat. Not until late in the war would some of these artificial limitations be overcome.[8]

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[8]FEAF ECM Study, pp. 18-19; FEAF Bomber Command Digest, November-December 1950, K713.197, AFHRA; David B. Morse, "Eye in the Sky: the Boeing F-13", Journal of the American Aviation Historical Society, Vol 26, #2 (Summer 1981), pp. 165-166; John T. Fahrquhar, unpublished study "Eyes of the Ferret: Strategic Aerial Reconnaissance in the Korean War", which cogently observed that one of the major organizational failures of the Air Force during the war was the lack of an organization devoted to managing the overall reconnaissance program, in marked similarity to the Air Force EW program; FEAF ECM Study, Annex I, "Operating Instruction 10-1, ECM Reconnaissance by Bomber Aircraft, 16 March 1951".

As bombing operations moved closer to the Yalu, the North Korean and Chinese defenses began to play a more active and significant role. The EW radar net on the far side of the Yalu provided sufficient warning time for MIG fighters to intercept the B-29 formations. In late February and early March 1951 several formations were intercepted and harrassed. Although none of the bombers were lost, this was obviously a training period for the defenses, which efficiently vectored fighters into intercept positions via GCI radar. Finally, on 12 April 1951, the defenses felt strong enough to press home their attacks. On that day a formation of over 100 fighters attacked 39 bombers near Sinuiji, across the Yalu from the main Chinese base at Antung. The 80 USAF escorts (primarily F-84 "Thunderjets") were no match for the MIGs, which evaded them and tore into the bombers. Three of the B-29s were lost and several more damaged. The B-29 was a rugged, well-armed airplane capable of absorbing a great deal of damage, but it was at far too great a disadvantage against modern jet fighters to operate in daylight much longer. Throughout the summer of 1951 they found themselves surprised by MIGs, vectored to the bombers by GCI radar.[9]

Despite the existing deficiencies in personnel and material, FEAF was aware of the need to plan for the future use of ECM. On 24 November 1950, the day before the Chinese intervened, FEAF/BC published "Policies and Procedures Regarding

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[9]Joseph G. Albright, "Two Years of MIG Activity", AUQR, VI, #1 (Spring 1953), p. 84; FEAF Bomber Command, "Heavyweights Over Korea", pp. 104-106; David Rees, Korea: the Limited War, (New York, NY: St. Martins, 1964), p. 373; Futrell, USAF in Korea, pp. 297-98.

Employment of Active ECM", which permitted only spot jamming operations, and even those were to be strictly controlled by FEAF. In response to Bomber Command requests for additional guidance, FEAF revised and expanded its instructions on 17 April 1951. It loosened the restrictions on spot jamming, which was now permitted whenever needed, but it also stated that barrage jamming, use of chaff, or communications jamming were prohibited without specific approval from FEAF. A few days later the prohibition on barrage jamming in the Pyongyang area was relaxed, but the others remained inviolate. In the case of chaff the restriction was likely an attempt to avoid revealing new types and tactics to Soviet scrutiny, while the ban on active communications countermeasures, which would probably have been very effective against GCI fighter control links, resulted from the desire to keep intact this source of valuable intelligence data. Bomber Command then published (on 29 June 1951) a new operating instruction for "Electronic Jamming", which established a tactical doctrine for the employment of spot jammers against gun-laying radars.[10]

Actual ECM operations started on 10 April 1951, when B-29s jammed enemy gun-laying radars near Pyongyang. The tactical doctrine employed was very similar to that used by SAC bombers engaged in the testing program at Eglin AFB. The jamming transmitters were turned on at the "initial point" (IP), approximately 40

[10]FEAF ECM Study, Annex IV, "ECM Summary, 1 September 1951", and Annex V, "Operating Instruction 11-1, "Standard Operating Procedure for Electronic Jamming", 29 June 1951.

miles from the target, and not turned off until the aircraft were out of the target area defenses. The 12 April mission to Sinuiji also used ECM, with uncertain results. It was difficult to evaluate how well ECM was performing, since the missions were conducted during daylight, but intelligence specialists did note that the Chinese were making observable changes to their radar procedures and that AAA was "extremely inaccurate" on cloudy days or at night. During the summer of 1951 FEAF/BC emphasized training radio operators in ECM operations, and in July, following a visit by SAC Vice Commander General Tom Powers, SAC agreed to send twelve more radio/ECM operators to each of the three bomber units. Starting in August FEAF began modifiying the B-29s to install an acceptable crew position for the ECM operator. If ECM offered a means of reducing losses and increasing effectiveness, FEAF was going to take advantage of it.[11]

As the summer of 1951 wore on the B-29s encountered increasing fighter opposition, climaxing in the "Battle of Namsi" on 23 October. By mid-October the Chinese fighter force north of the Yalu included approximately 525 MIG-15s, and it had been gathering experience all summer in using GCI radar to intercept the B-29 formations. In October FEAF/BC initiated a campaign against a series of airfields which the Communists were building in North Korea. On 23 October the 307th Bomb Group sent eight B-29s against the airfield at Namsi, escorted by F-86 "Sabrejets" and F-84 "Thunderjets". Alerted by their EW radars and guided to the

[11]FEAF ECM Study, pp. 1-4, and Annexes IV and V, cited above.

bombers by GCI the MIGs arrived in force, attacking the bombers right from the IP through the target. It was a debacle: three of the bombers were shot down (a few crewmembers were rescued by Search and Rescue) and the other five damaged. Two were so badly damaged that the 307th Bomb Group doubted they would ever fly again, and one aircraft had its navigator killed and five other crewmen wounded. The 307th lost two of its twelve enlisted radio/ECM operators on this mission. Within a few days FEAF/BC made the difficult but correct decision to halt daytime operations.[12]

Air Force Chief of Staff General Hoyt S. Vandenberg was not enthusiastic about the decision, which he viewed as an admission of defeat. But there was no way around it. The commander of Bomber Command, Brigadier General Joe Kelly, told General LeMay that there simply were not enough escort fighters available, and that FEAF's limited number of F-86s could be better used on other, more aggressive missions. General Vandenberg visited Korea in November 1951 prepared to rebuke FEAF for its decision to halt daylight B-29 operations: he left fearful for SAC's ability to penetrate Soviet airspace and carry out the atomic strike plan. Upon his return from Korea the Air Staff studied the issue of operations versus the MIG-15. Although several concepts were suggested for improving escort tactics, the one that was adopted was to equip the bombers with SHORAN (SHort RAnge Navigation), a form of electronic triangulation which provided accurate navigation even at night or

[12]307th Bomb Wing unit historical report, October 1951; Rees, Korea. the Limited War, pp. 373-74; Futrell, USAF in Korea, pp. 410-12.

through clouds and conduct operations at night. Air Force officers at the Air University also had several suggestions for dealing with the North Korean radar system, including jamming the fighter control radio frequencies, improving friendly early warning radars to provide warning of when enemy fighters were assembling for an attack, and mounting an aggressive radar suppression program against enemy EW, GCI, and AAA control radars. One aspect of the last suggestion was the need for tactical units to possess an ECM reconnaissance capability, which was hampered by the lack of a suitable airborne direction finder for enemy radars.[13]

An obvious question at this point might be: if the enemy was so dependent on radar, why didn't the B-29s just jam the EW and GCI radars and fighter control links and thus avoid the fighters? Two factors are involved in why this was not feasible. Firstly, the small B-29 formations of no more than a few dozen bombers simply did not have sufficient jamming power to overcome the widespread and overlapping enemy radars. After all, if the massive bomber formations of World War II (using essentially the same equipment) could not prevent detection of a raid, six or seven B-29s over Korea certainly could not, and the use of active ECM could serve as its own warning to the defenders that aircraft were approaching. It might even provide a means for fighters to home in on the bombers. Secondly, the shortages in

[13]FEAF Bomber Command, "Heavyweights Over Korea", p. 110; A. W. Jessup, "MIG Attack on B-29 Calls A-Bomb Delivery Capability into Question", Aviation Week, 56 (4 February 1952), p. 16; Letter, Air Force Deputy Chief of Staff for Operations, Control Division, to Commanding General, Air University, 20 December 1951, subject: "Air Operations in Korea Against the MIG-15", K239.187-1, AFHRA.

equipment and trained personnel compounded the difficulties involved in providing an effective electronic screen. The inability of the bombers to avoid detection was the result of a combination of factors, but the end result was that they had to abandon daylight operations. Night operations, however, were to provide only a temporary respite from the Chinese defenses.

Phase Two: Night Operations

The next stage of B-29 operations now began, using SHORAN to permit the bombers to carry out accurate bombing missions at night against airfields, rail yards, supply depots and other such targets. Beginning in June 1951, the 98th 19th and 307th Bomb Wings were equipped with the needed equipment, and although full capability was not attained until 1952, this became the B-29s' primary method of operation after November 1951. At times the bombers dropped leaflets, warning the population of targeted towns to "clear out" before the bombers struck. This was in part a humanitarian gesture and in part a shrewd bit of propaganda which brazenly demonstrated that the bombers could go anywhere they wanted, even at night.[14]

The switch to SHORAN operations was not a panacea, however, and it brought with it a new series of problems which affected Bomber Command's ECM capability. The SHORAN equipment required approximately half of the electrical power which was previously available for the ECM gear, thus degrading the

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[14]FEAF Bomber Command, "Heavyweights Over Korea", p. 108; Futrell, USAF Over Korea, pp. 385-86, 487; in 1951 the Air Force carried out an organizational change in the structure of its combat units, replacing "groups" with "wings" as the central flying unit.

jammers' effectiveness. More serious was a problem with mutual interference: when one system was switched on the other would not operate properly. The temporary solution was to simply turn off the jammers while the aircraft was making its bomb run; unfortunately, if the target was defended by searchlights and AAA this was precisely when ECM was most needed. Even with this limitation the jammers themselves provided effective protection against short-range searchlight and AAA control radars. Each bomber normally had four equipment mounting racks available for ECM gear, and usually carried an APR-4 receiver (to detect radar signals) and three jammers, the APT-1, APQ- 2 and ARQ-8 transmitters. Some aircraft substituted a pulse analyzer for a jammer if more intelligence on the radar signals was desired.[15]

The experience and proficiency of the enlisted radio/ECM operators sent to FEAF/BC was a second and even more intractable problem area. As early as January 1951 the 19th Bomb Wing instituted an "extensive" ECM training program for the operators, which had to be repeated for those ECM operators who arrived in July, September and November 1951. The 21st Air Division, at Forbes AFB, Kansas, was responsible for the stateside training of B-29 crews heading for Korea, and SAC stressed that ECM, along with bombing and gunnery, was of the "greatest importance". Unfortunately, the situation in mid-1951 can best be described as chaotic. The 21st Air Division lacked ECM instructors, equipment mock-ups, C-47s

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[15]5th AF historical report, pp. 73-77, July-December 1951, K.713.01-20, AFHRA; FEAF ECM Study, p. 8.

for airborne training: in short, nearly everything necessary with which to conduct an effective training program. In the spring of 1952 the commander of FEAF Bomber Command identified ECM training as one of the five major deficiencies he had noted in the crews Bomber Command was receiving, and in May the training program was revamped to add increased emphasis to ECM. Upon their arrival at Forbes AFB all radio/ECM operators were placed in a training pool, and spent the first month intensively training in ECM. At least 125 hours were devoted to ECM, including time in the classroom, on mockups, and 45 hours in the air. They were then assigned to a regular crew for their second and third months of training. The intent of this training flow was to insure that the new ECM operators received ECM training before they were integrated into the normal crew training scheme.[16]

In practice, however, this program did not function as well as had been planned. In a postwar report on the use of ECM, FEAF/BC attributed the shortcomings in the stateside ECM training program to insufficient motivation of the ECM operators and excessive compression of the training program. This agreed with the observations of the 98th Bomb Wing Director of Operations, who reported on the wing's operations between March and September 1952. His comments on the training of crews before assignment to Korea are worth quoting: "these people have been 'hustled' through a

[16]20th AF historical report, Vol I, pp. 74-75, July-December 1951, K760.01; 21st Air Division historical report, pp. 111-113, July-December 1951; Letter, Commander FEAF Bomber Command to Commanding General, 21st Air Division, 24 April 1952, and Letter, 21st Air Division Director of Operations to Commander, 980th Bomb Wing, 13 May 1952, subject: Replacement Crew Training; both in 90th Bomb Wing historical report, May 1952.

training program where highly technical information, essential to their efficiency as a crew - essential even to their continued existence on earth - has slipped by them." Not until they arrived in theater and began combat operations did they begin to really learn ECM operations.[17]

One of the most important things they had to learn was that the enemy's defensive tactics were evolving in response to Bomb Command's switch to night operations. Until that change, the ECM operator's primary focus was on jamming enemy AAA control radars. Now the primary threat to the B-29s came from a system which the Luftwaffe had called *Helle Nachtjagd*, or illuminated night fighting, in which radar-controlled searchlights illuminated a bomber and GCI-guided fighters then attacked it visually. By late 1951 the enemy had established a line of radars extending from the Yalu into North Korea which appeared to serve as a control system for directing MIG fighters from their bases to operational areas south of the Yalu. Searchlight radars became active in October 1951 and sightings increased through the end of the year. The first coordinated use of searchlights and fighters took place on 23 December 1951, near Uiju airfield, in which two B-29s were damaged. Fifth Air Force estimated that the enemy EW/GCI radar net could provide coverage from Seoul to the present-day Demilitarized Zone on Korea's east

[17]FEAF ECM Study, p. 17; 98th Bomb Wing Director of Operations, "Special Narrative Report, Bombardment Operations of 98th Bomb Wing", 24 September 1952, in K720.310-69, AFHRA.

coast, an area which included the entire zone of B-29 operations.[18]

If the enemy GCI net had depended on the equipment they possessed at the start of the war the threat would not have been severe, but by the fall of 1951 the Air Force had obtained ominous evidence of a vastly improved Soviet radar, nicknamed "Token". The US Air Attache in Moscow had obtained photographs of a new radar which bore a marked resemblance to the American CPS-6, the most modern GCI radar in use by the US. With five transmitters operating in the S-Band frequency range (about 3000 MHz), not only could the Token radar control several fighters simultaneously at ranges up to 70 miles away, it also operated in a frequency range against which FEAF had no jamming capability. Indeed, SAC had only a few jammers throughout the entire command effective against it. In January 1952, a 5th Air Force intelligence summary stated that Token by itself did not improve Soviet night interception capabilities. This would shortly be proven erroneous, as the Russians would soon use Token to vector fighters into attack position against bombers illuminated by radar-controlled searchlights.[19]

The tactic of using GCI radars to vector night fighters into attack position

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[18]Streetly, Confound and Destroy, p. 214; "Enemy Air Defenses, 25 June 1950 - 15 February 1952", in 5th AF historical report, Vol II, January-June 1952, K730.01; FEAF "Report on the Korean War", Book 2, p. 16, 15 February 1954, K720.04D, all in AFHRA.

[19]Richard E. Fitts, The Strategy of Electromagnetic Combat, (Los Altos, CA: Peninsula Publishing Co., 1980), p. 59; "Development of SAC ECM Program", pp. 75-76; FEAF ECM Study, Annex III, "ECM Summary, 1 June 1951"; 5th AF Intelligence Summary, 7-31 January 1952, K730.607, in AFHRA.

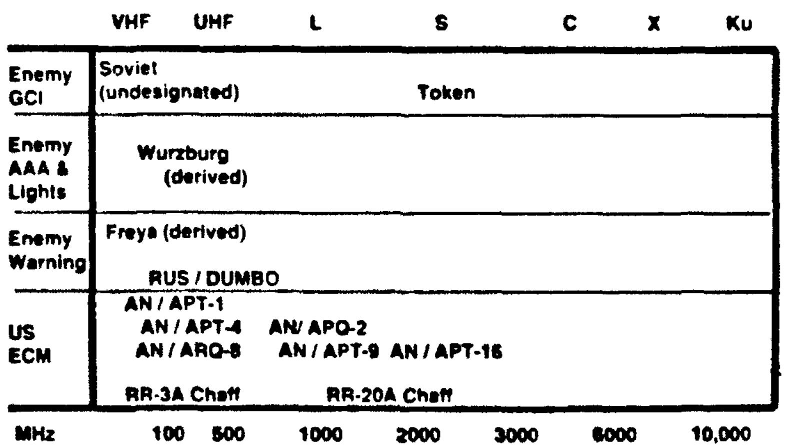
against illuminated B-29s was the only effective defense the enemy had against their new mode of operations, and the North Koreans' tactical sophistication gradually improved. They used small groups of six to eight radar-controlled lights as guides for twelve to fifteen manually-controlled ones, and with many searchlights guarding key targets the threat that a bomber would be illuminated long enough foı fighters to locate it and attack was growing. This situation was made worse by the limited number of approach routes which the B-29s could use, an inherent weakness of the SHORAN system. Although the North Korean defenses were heaviest in the area between the Yalu and the Chongchon Rivers (the area known as "MIG Alley"), this was were many of the mos: important targets were located. Soon there would not be any "safe" places left for the B-29s to operate, even at night.[20]

The ECM equipment available to the B-29s at the start of night operations, such as the old World War II-era APT-1 and ARQ-8 jammers, fortunately was adequate against the limited enemy capabilities. The 19th Bomb Group reported several instances in November 1951 of enemy radar-controlled AAA being effectively jammed, and as the enemy use of radar increased so did the use of ECM. Bomber Command noted 25 jamming attempts in August 1951; by November it had mounted to 112, and to 189 in December. It was reassuring to a bomber crew to watch enemy flak become inaccurate, and it was especially gratifying to watch the dreaded

[20]After Action Report, Colonel Julian M. Bleyer, 19th Bomb Group Commander, January-July 1952, in 19th Bomb Group historical report, 24 July 1952; Jackson, Air War Over Korea, p. 144; FEAF Bomber Command, "Heavyweights Over Korea", pp. 111-113; Hallion, The Naval Air War in Korea, p. 170.

searchlights lose track and begin wildly sweeping the sky to try to reacquire the bomber. As more crews experienced such proof of the utility of ECM its stock rose within Bomber Command. There is a sense of deja vu here, however, for this was precisely the same pattern as seen during World War II. Somewhere along the line the bomber crews hadn't "got the word": ECM helped hold down losses. At some point between the SAC senior leadership and the bomber crews the system had broken down. "Lessons learned" during World War II had not been organizationally incorporated, and mid-level leadership failed to emphasize those lessons. As a result, the Air Force was learning them all over again, and paying for those lessons in the only currency available: airplanes and crews.[21]

Figure 6
Frequency Bands & Radar/ECM Gear



[21]FEAF ECM Study, Annex X, "Effectiveness of Electronic Jamming", 6 December 1951, and Annex IX, "ECM Efforts of Bomber Aircraft from 1 August to 1 December 1951"; FEAF ECM Study, pp. 4-5, in AFHRA.

Sooner or later the enemy night defensive system was going to have a major success, and it came on the night of 10-11 June 1952. That night the 19th Bomb Wing dispatched a small force of bombers against the railroad bridge at Kwaksan, near the southern end of "MIG Alley". Up to two dozen searchlights caught the bombers, and an unidentified aircraft trailed the B-29s. This was probably an airborne commander for the defenses, who could radio back information on the speed, altitude, heading and strength of the attackers. Almost as soon as the searchlights came on the bombers were attacked by up to a dozen MIGs. One B-29 exploded over the target, and another went down shortly thereafter. A third, which had to make an emergency landing, suffered damage which attested to both the viciousness of the attack and the ruggedness of the B-29. Due to the ECM-SHORAN interference problem referenced earlier this bomber made a second run over the target, during which it came under heavy attack. The tail was severely damaged, two feet of the left wing was shot off, the ship was explosively decompressed and lost all hydraulics, one engine was knocked out and two others had only partial power, and the fuselage from nose to tail was riddled with over 500 holes! None of the aircraft used chaff, which was prohibited by FEAF policy, and only one aircraft jammed the enemy radar by breaking its tracking lock and escaping into the darkness.[22]

Phase Three: Electronic Battles

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[22]Futrell, USAF Over Korea, p.425; 19th Bomb Wing historical report, June 1952; FEAF ECM Study, p. 10; Hallion, The Naval Air War in Korea, p. 170.

The disaster over Kwaksan marked the end of the "safe" phase of nighttime B-29 operations, and from now to the end of the war Bomber Command would have to counter the radar and searchlight MIG defensive team. The first step in this process was to gather intelligence, and beginning in mid-1951, the Air Force significantly improved its ELINT-gathering capability in the region with the dispatch of RB-50s from the 55th Strategic Reconnaissance Wing. Later in the war the RB-50s even accompanied the B-29s on strike missions, to obtain ELINT while enemy radars were actually being employed in combat. But signal intelligence (or SIGINT) could only yield so much information: limitations in the direction-finding capability of the RB-50s often meant that precise information on the location of the enemy radars was unobtainable. This, in turn, made it difficult to target those radars for destruction by the 5th Air Force's tactical bombers. (That story, however, will be left for a later chapter.) The effort to improve the ELINT program led to the establishment of the 548th Reconnaissance Technical Squadron (called "recce tech"), which worked closely with the 91st Photo Reconnaissance Squadron and the RB-50s from SAC to speed the evaluation and dissemination of vital information on enemy electronic systems. These improvements led to a more timely and detailed enemy electronic order of battle (EOB), which listed where enemy radars were located, their technical details (frequency, pulse rate, etc), range, and all the other information which bomber crews needed.[23]

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[23]Ibid., pp. 108-109; FEAF ECM Study, p. 7; FEAF Bomber Command, "Heavyweights Over Korea", pp. 112-113; Futrell, USAF in Korea, pp. 572-575.

Far East Air Forces made other organizational changes which indicated a greater awareness of the importance of high-level involvement in the ECM program. Bomber Command headquarters was reorganized to improve ECM effectiveness. The Intelligence division was augmented by a qualifed ECM officer, and in mid-1952 the officer who had been in charge of ECM in the Communications-Electronics division was moved to Combat Plans, resulting in a much closer integration of ECM into the operational planning process. This was made possible by additional ECM officers (SSN 7888) being assigned; between July 1951 and January 1952, for example, the number of ECM officers in 5th AF doubled.[24]

The personnel situation regarding enlisted radio/ECM operators also underwent changes. In September 1952 FEAF/BC authorized a full-time ECM operator for each B-29 crew, who would be relieved of his duties as a radio operator. The previously-mentioned difficulties with the stateside ECM operator training program, however, were now manifested in a shortage of experienced ECM operators in the combat theater. As the need for ECM grew so did the demands on the operators. The 98th Bomb Wing reported in June 1952 that although its daily sortie rate reached at times 16 aircraft, it only had 11 ECM operators available for any one mission day. The result was that some of them flew several additional missions per month than did the average combat crew. This in turn led to lower morale and degraded proficiency. This situation was aggravated by the way in which ECM

[24]FEAF ECM Study, p. 7; 5th AF, Communications-Electronics Division, 1 January 1952, K730.901A, in AFHRA.

operators were sent to FEAF. Throughout the war they reported in as "filler" personnel, who were then placed in a pool from which radio operators were taken as needed. After each B-29 crew was authorized a full-time ECM operator Bomber Command wanted the units to assign the older and most experienced ones to ECM duties, leaving the newer and inexperienced men to handle the radio duties. The bomber units, however, resisted this because of the possible negative impact on "crew integrity". The implication is clear: at the lowest levels, the bomber crews and squadrons, ECM was still thought of as something "special" and not as a part of the day-to-day operational mission.[25]

Throughout the remainder of the war the enemy continued to expand and improve both radars and defenses. The early warning (EW) radar net extended from many locations in central North Korea deep into Manchuria and along the Yalu, thus providing overlapping coverage. The June 1953 enemy EOB, for example, listed 28 confirmed EW radars. The linchpin of the system was the base at Antung, at the mouth of the Yalu across from Sinuiji, where several different types of radars were located. From Antung early warning radars could detect American aircraft from more than 100 miles away. Although most of these were old World War II-era sets, there were some modern ones that operated in the 1000 to 3000 MHz frequency bands. Over 20 GCI radars had been positively identified, and many of the EW sites could also accomplish GCI for the enemy fighters. An S-band radar of the Token

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[25]98th Bomb Wing historical report, June 1952; FEAF ECM Study, pp. 16-17, in AFHRA.

type was identified at Antung, from where it could control fighters out to nearly 100 miles.[26]

The GCI radars by themselves were only half of the problem, however, for at night the MIGs would have been little threat without the searchlight control radars that enabled the searchlights to illuminate the bombers. Most of them operated in the lower freqency ranges, between 100MHz and 200MHz. By mid-1953 Bomber Command had identified over thirty locations where searchlight radars had operated, most of them being within the not-so-friendly confines of "MIG Alley". The fighter-searchlight team was an effective means of defense against the small B-29 raids, which could not afford to lose many aircraft. The enemy defensive system could have been made far more lethal if the Soviets had chosen to equip the fighters with airborne-intercept radar (AIR), but there were no confirmed reports during the entire war of the MIGs using such a system. The Soviets had tried to develop an airborne radar during World War II, but it was several years behind the quality of American or British sets. Although the Russians had captured examples of the Germans' "Lichtenstein" and "Naxos" radars, it does not appear that they were used in Korea, probably because the Soviets did not want to reveal the extent of their AIR capabilities.[27]

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[26]5th AF Intelligence Summary, 1-15 September 1952, K730.607; FEAF ECM Study, Annex VIII, "Radar Order of Battle for North Korea", 6 June 1953, in AFHRA.

[27]Ibid.; Steven J. Zaloga, "Soviet Air Defense Radar in the Second World War", The Journal of Soviet Military Studies, I, #4 (December 1988), pp. 543-545; Lee, The Soviet

To protect the B-29s Bomber Command developed a variety of tactics, several of which did not involve Electronic Warfare at all. During the cold winter months, for example, it was common for contrails to form behind the bombers, long white arrows pointing out their direction, so missions were planned to avoid the altitudes at which the contrails formed. Avoiding bright, moonlit nights was another tactic, for the moonlight, especially when combined with contrails, gave the defense a valuable visual assist in locating the bombers. The most effective natural countermeasure was a thick cloud layer between the bombers and the searchlights, but the bombers had no control over whether or not the clouds would be present when needed, so they borrowed a tactic from World War II and painted their undersides jet black, to reduce the reflection in case they were caught by searchlights. The planners had some flexibility in the altitudes at which attacks were made, so they tried to take advantage of local weather conditions, avoiding those that favored the formation of contrails, and to find clouds which could block the searchlights. Finally, the planners compressed the length of the bomber stream by reducing the interval between aircraft, which thus reduced the amount of time the entire formation was exposed over the target area. During the disaster over Kwaksan, for example, the small bomber formation was over the target for more than half an hour, far too long for safety. Reducing the interval between aircraft from three minutes to one reduced the period of vulnerability by 66%. This had an added benefit of increasing the

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Air and Rocket Forces, p. 122; Robin Higham and Jacob W. Kipp, Soviet Aviation and Air Power: a Historical View, (Boulder, CO: Westview Press, 1977), p. 222

effectiveness of the bombers' jamming efforts by bringing the transmitters closer together and thus increasing the effective strength of the jamming signals.[28]

If the B-29s were going to operate when necessary, however, they could not afford to wait for moonless nights and heavy cloud cover: they needed a more consistent means of defeating the enemy electronic defenses. Bomber Command focused on negating the three critical parts of the enemy defensive system: the radars themselves, the searchlights, and the MIGs. As early as December 1951 the 307th Bomb Group employed a B-29 in the old World War II "Guardian Angel" role of ECM escort. This was necessarily a rudimentary effort: the unit ECM officer used it as a checkride for two enlisted radio operators, although the lack of any gunlaying radars in the target area made it difficult to assess their effectiveness! Less than a year later, however, this tactic had evolved to such a degree that on the 12 September 1952 mission to Suiho, seven B-29s flew a figure-eight pattern in the target area while jamming GCI and target acquisition radars. This was in addition to the jamming efforts of the bombing force of more than fifty B-29s, which jammed GCI, searchlight and gun-laying radars. This operational concept was repeated later in the month, during the 30 September mission against the Namsan-Ni chemical plant, in which the overall bomber force of sixty B-29s included half-a-dozen

[28]Futrell, USAF in Korea, pp. 572-575; FEAF Bomber Command, "Heavyweights Over Korea", pp· 112-113.

devoted to ECM escort.[29]

Bomber Command was also assisted by the Marines, who flew night escort missions starting in the summer of 1952. The "Flying Nightmares" of Marine Fighter Squadron 513 flew F3D "Skyknight" fighters (informally and derisively called "blue whales" because of their large size), which were equipped with no less than three on-board radars. After coordinating with Air Force planners in August 1952, the Marines at first used the B-29s as bait, taking advantage of the MIGs' propensity to go after the bombers to test their own night-fighting capability. Operating under American radar control, the Marines flew two types of missions, either flying along with the bomber stream in a sort of close escort, or else orbiting in a barrier pattern between the bomber stream and the MIGs' bases.[30]

The Air Force also had night fighters in Korea, in fact had been there longer than the Marines: the 319th Fighter Interceptor Squadron had been at Suwon since December 1951. But the 319th was equipped with the Lockheed F-94 "Starfire", and fear of compromising its state-of-the-art electronics package in case one should be lost over enemy territory led the Air Force to restrict its use to operations south of the battlefront. Since the Marines used an older radar system they drew the assignment to hunt MIGs after dark, and they accepted the assignment with gusto. Twice in November 1952 they shot down MIGs after being vectored into attack

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[29]307th Bomb Wing historical Report, December 1951; FEAF Bomber Command historical report, July-December 1952, K713.01-30, in AFHRA.

[30]Hallion, The Naval Air War in Korea, pp. 173-179; FEAF ECM Study, p.6.

position by American GCI radars, and in January 1953 they bagged three more. In November the Air Force's F-94s were cleared to "go north" too, and in June they added another MIG to the night-fighters' tally. It is difficult to assess how effective the Marine and Air Force night-fighters were in reducing B-29 losses. Certainly they made the MIGs' task more difficult and hazardous, which in turn must have impaired the efficiency of the radar-searchlight-MIG defensive team. Also, it was never conclusively settled whether the MIGs were using an airborne intercept radar (AIR), although by then the Soviets had a working model of the Izumrud S-band AIR installed in at least a few MIG-l5bisP model fighters. The intelligence experts said no, the bomber crews often said yes, but the key point is that even if the Soviets tested it in Korea they did not use it extensively, fortunately for the bombers, which would have been extremely vulnerable.[31]

The missions to Suiho and Namsan-Ni in September 1952 also saw the introduction of two more countermeasures, direct attacks on the searchlights, and the use of chaff. Two 5th Air Force B-26s (the World War II A-26) claimed to have destroyed eight searchlights on the mission to Suiho, while on the mission to Namsan-Ni later in the month no less than seven B-26s attempted to supress some of the more than forty searchlights in the target area. Marine Corps F7F night fighters (an older, propellor- driven aircraft) escorted the medium bombers into the target

[31]Francis J. Amody, "We Got Ours at Night", American Aviation Historical Society Journal, Vol 27, #2 (Summer 1982), pp. 148-150; Hallion, The Naval Air War in Korea, pp. 179-187; "Night Fighters in Korea", Aviation Week, Vol 58 (9 February 1953), p. 14.

area on 12 September, to protect the bombers from enemy night fighters. Afterwards, 5th Air Force decided that the searchlight suppression missions were unsuccessful. They only destroyed about one-fourth of the searchlights in the target area, the flares which the B-29s dropped to illuminate the area also exposed the B-26s, and many of the lights were in Manchuria, across the Yalu and immune from attack. Although no one knows how many searchlights were actually destroyed, direct attack of ground-based defenses such as searchlights indicates how seriously Bomber Command considered elimination of the lights as necessary to keep losses down.[32]

Ironically, the most effective countermeasure employed by Bomber Command was also the oldest one: chaff. For the first two years of the war FEAF prohibited its forces from using chaff, to prevent the Soviets from learning anything about the Air Force's chaff capability. This was unnecessary, since the chaff that Bomber Command possessed was of the same World War II-vintage as its APT-1 jammers and the Russians almost certainly had obtained samples during the war. This prohibition was indicative of the widespread belief that the war in Korea was merely a precurser to a larger US-Soviet conflict in Europe, a conflict that would require US forces to employ every advantage, no matter how slight, to defeat the Soviets. An added factor was that the B-29s were not suffering such serious losses at night that their operational utility was imperiled. In late August 1952 the JCS suggested to the

[32]FEAF ECM Study, Annex XXII, "Report-Searchlight Suppression", 12 September 1952.

Far East Command that its policy on ECM use was too restrictive, and a few weeks later, starting with the 12 September mission to Suiho, FEAF began employing chaff in the most sensitive and dangerous areas near Pyongyang and along the Yalu.[33]

The results were dramatic: on the 12 September mission against the hydro-electric plant at Suiho, for example, two of the ECM escorts orbited twenty miles east of the target for over an hour, dropping two different types of chaff (RR-3A/U, effective in the low frequency range, between 25-350 MHz, and RR-20A/U, effective in the higher frequency ranges, including the S-band, between 850-30,000 MHz) to jam acquisition and GCI radars. The main bomber force also employed chaff, some dropping it continuously while others dispensed it at random intervals. Coordination between the flak and seachlights batteries was poor, and seven aircraft reported that searchlight "lock-ons" were broken by their use of chaff and jamming. Another indication of how effective ECM was on this mission was that the fighter opposition was heavier at the start of the attack than at the end, which was contrary to the usual pattern.[34]

The performance of the different bomber units on this mission provided some

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[33]FEAF ECM Study, Annex XX, "Summary of Chaff Utilization in Korean Theater", 26 October 1953; Letter, General HQ, Far East Command to Commanding General FEAF, 17 March 1952, subj: Far East Command Electronic Countermeasures Policy, JCS 222/18, in RG 311, Section 8/box57, NARS, Washington, DC; FEAF Bomber Command historical report, January-July 1953, K713.01-36, in AFHRA.

[34]FEAF ECM Study, Annex XX; FEAF Bomber Command historical report, July-December 1952, K713.01-32, Annex 1, "Staff Study on the Use of Chaff by FEAF Bomber Command", in AFHRA.

interesting information for future analysis. The first unit, the 307th Bomb Wing, arrived at the target virtually bereft of any ECM capability. Five of its ECM-equipped aircraft had aborted the mission, and it had been tasked to provide four of the eight ECM escorts. As a result, only one of the first eleven bombers over the target performed any jamming, and only two dropped chaff. The unit reported "intense accurate flak and searchlights" and considerable fighter activity: seven aircraft reported fighter attacks, and one aircraft was illuminated by lights and shot down by a fighter. The next unit, the 19th Bomb Wing, had five of its nine aircraft dispense chaff, and it fared somewhat better, losing none but suffering eight aircraft damaged by flak. The last unit, the 98th Bomb Wing, put twelve aircraft over the target, with nine dispensing chaff and eight jamming enemy radars. Although four aircraft were damaged by flak, only one reported a fighter attack. The implication seemed clear: ECM and chaff played a significant role in disrupting the enemy defenses and thus preventing losses.[35]

Eighteen days later Bomber Command was back in force, this time to strike the chemical plant at Namsan-Ni on the Yalu, and a comparison of the two missions provided a sort of controlled test of ECM effectiveness. The 98th Bomb Wing, which had been the last unit over the target on the 12th, this time led Bomber Command. Of its fourteen aircraft, ten used jamming and eleven dropped chaff: none reported fighters and only two were damaged by flak. The 19th Bomb Group,

[35]Ibid.

on the other hand, put seventeen aircraft over the target, but only nine jammed enemy radar and even fewer, six, dropped chaff. The correlation between its lesser use of ECM and the significantly greater degree of opposition it faced and damage it suffered (seven aircraft were attacked by fighters, and five of the bombers were damaged by flak) may have been more than just coincidence. Those aircraft which did employ chaff and ECM, however, reported that enemy searchlights could be seen congregating on and illuminating empty sky, evidently chaff concentrations which enemy radar operators believed were actually bombers. As on the earlier mission, chaff employment centered on three tactics. Continuous chaff drops by some bombers were an attempt to screen the bombers from enemy radar by creating a chaff "corridor" through which the bombers could fly. Random or intermittent chaff drops attempted to mislead the enemy radar operators as to the size and location of the real bomber force. The third tactic, burst or emergency chaff drops, were a last-ditch attempt by a bomber to break the radar lock of a searchlight or flak battery which had located an individual bomber. Although the statistical sample available in these two missions was admittedly small, the results of these two missions verified the experiences of World War II: ECM cut losses.[36]

What made these results so remarkable was that Bomber Command was still using equipment which dated back to World War II, and was employing chaff and chaff dispensers which were highly unreliable. Bomber Command still did not have

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[36]Ibid.; FEAF ECM Study, Annex XX; 19th Bomb Wing historical report, July-December 1952; all in AFHRA.

a jammer effective against the Token radars operating in the S-band frequency range, and none of the other jammers it possessed was available in sufficient numbers to fully equip any of the bomb wings. Even though the space and power limitations described earlier restricted each bomber to no more than two jammers, this still meant that on major missions such as Suiho or Namsan-Ni the total bomber force carried a wide variety of jammers, effective against a range of radar frequencies. If this blend happened to match those radars in the target area the bombers would be well protected, but there was no certainty that this would happen. The effectiveness of the chaff drops were seriously affected by problems with dispensers and chaff. Approximately 50% of the chaff loaded for these missions was never dropped, due to malfunctions. Of these failures, fully three-quarters resulted from one of four causes, especially breakage of the old, paper-backed chaff tape (it dated to 1945) or jamming of the exit chute within the dispenser. Although Bomber Command took aggressive and successful action to reduce the number of failures, it could not change the fact that it was operating with equipment that was at least obsolescent if not outright obsolete.[37]

Between the first of November 1952 and the end of January 1953 Bomber Command lost five more B-29s, then operated unscathed through the rest of the war. Some of the losses were probably unavoidable. On 18 November, for example, a B-29 was shot down by fighters after being caught in a cone of searchlights. A

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[37]FEAF ECM Study, Annex XX; FEAF Bomber Command historical report, July-December 1952, K713.O1-32, and January-July 1953, K713.01-36, in AFHRA.

survivor from the crew said that the ECM operator on board reported "so many radar signals he could not jam them all." Another bomber, shot down on 30 December, was producing contrails and being shadowed by an enemy aircraft which was evidently radioing information on the bomber's speed, altitude, etc. to waiting interceptors. To make matters worse, the moonlight was sufficiently bright to make the bomber visible against the snow-covered fields below. In other words, it was a sitting duck which no amount of ECM could protect.[38]

The last months of the war saw continued refinement of Bomber Command's ECM tactical doctrine, such as the standardized procedure for emergency chaff drops published in late November 1952. Bomber Command also prioritized which radars should be jammed first, starting with the searchlight control units, then GCI radars, and finally early warning sites. Although Bomber Command never did get a satisfactory counter to the Token GCI radar, that was not the critical link in the enemy defensive system. The link that had to be broken was the searchlight control radar, because the entire defensive effort rested on illuminating the bomber so the MIG could see it to attack. Fortunately for the B-29s, the only searchlight control radar the North Koreans consistently used operated at about 200 MHz, which could be effectively countered by both RR-3A/U chaff and the APT-4 jammer. During the final six months of the war FEAF flew over 4000 bomber and heavy reconnaissance

[38]Jackson, Air War Over Korea, p. 151; FEAF ECM Study, Annex XVII, "Staff Study of the Effectiveness of ECM as Employed by FEAF Bomber Command From 12 September - 24 December 1952", in AFHRA.

sorties, of which 534 reported sighting searchlights (13%). In 114 of these cases (20%) the searchlights illuminated and locked on to the bombers. The value of ECM was that in more than 75% of these cases (87) the bombers' use of jamming and chaff caused the searchlights to lose contact, thus breaking the critical link in the defensive system. After January 1953, no more B-29s were lost to enemy action.[39]

Combat Summary

Although B-29 losses during the war had been only a small percentage of the sortie rate (74 lost out of over 21,000 sorties, less than 1/3rd of one percent), the issue at question here is to assess how effective ECM was in holding down losses.[40] Shortly after the ceasefire took effect, FEAF undertook a staff study of just this question, to determine what measures had succeeded and why, and to suggest

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[39]FEAF ECM Study, Annex XIII, Letter, FEAF Bomber Command to B-29 Bomb Wings, "Chaff Emergency Procedures", 26 November 1952; FEAF Bomber Command historical report, July-December 1953, K713.01-36; FEAF ECM Study, Annex XIX, "Report on the Effectiveness of ECM Against Radar Controlled Searchlights in North Korea from 1 January thru 27 July 1953", all in AFHRA.

[40]The actual losses cited in the FEAF ECM Study, Annex XV, "Aircraft Losses - FEAF Bomber Command, 26 June 1950 Thru July 1953" were 21 to MIGs, 5 to flak, 9 to unknown causes, and 39 to "operational causes", some of which were undoubtedly related to battle damage. In return, B-29 gunners were credited with destroying 26 MIGs, as cited in Air Force Historical Study #81, "Victory Credits - Korean War", 101-81, in AFHRA. This low loss rate somewhat muted the question of whether an earlier relaxation of FEAF's prohibition against using chaff and jamming would have prevented some of the B-29 losses, for the loss of a few more or less B-29s did not impact SAC's overall war fighting potential, and was thus insignificant...except to the crews. It highlights the question of preserving operational capabilities that may be needed in the future, at the expense of greater attrition in current operations, and serves to remind us that although wars are analyzed statistically, they are fought by men; the percentage points in the dry statistics mean flesh and blood and life or death.

possible improvements The study concluded that after the switch to night operations in November 1951, losses and damage would have been three times greater if the bombers had not been able to employ electronic jamming and chaff. The most effective use of ECM was against searchlight and gun control radars, while the least effective use was against GCI and early warning systems. This was a factor of the precision and accuracy required of these systems. If the flak or searchlight was not accurately pointed at the target bomber it missed and therefore was ineffective. If the searchlight was able to illuminate a bomber, however, all the GCI radar had to do was get the fighter to the general vicinity of the target, because it could probably then see the target in the cone of light and make an attack.[41]

There were, however, several deficiencies in the FEAF ECM program, some of which were beyond Bomber Command's control or ability to solve. The personnel situation was such an example. Throughout the war there simply were not enough well- trained ECM operators to go around. Some of this was due to the stateside training program for B-29 replacement crews (previously discussed), and some was due to the relatively low priority accorded to the B-29 force, which was obviously headed for retirement and did not receive the high-level attention that creation of the coming all-jet bomber force (B-47s and B-52) received from both SAC and the USAF. As noted, FEAF did call attention to the need for more and better-trained

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[41]FEAF ECM Study, pp. 23-24; 98th Bomb Wing historical report, March 1953, in AFHRA

operators, but help was late in coming.[42]

Shortfalls in personnel were mirrored by equipment limitations. With the notable exception of a few next-generation jammers (primarily the APT-16, designed to negate enemy S-band radars), Bomber Command fought its electronic war with World War II-era equipment. Fortunately, so did its adversary for the most part. Korea did offer the Air Force the toughest testing ground possible, combat, and as a result learned some useful information. The SHORAN-ECM interference problem was one such example, and although the addition of the correct electronic filtering devices could alleviate this problem, it could not compensate for the fact that the B-29 was obsolete. It was not designed for the addition of such equipment, and by the early 1950s it had run out: run out of room and electrical power for additional racks of electronic equipment, run out of room and capacity for extra crewmembers, run out of combat usefulness. All in all, Bomber Command and the B-29 crews had done a superb job with the available equipment and capabilities, but the B-29 simply had no growth potential remaining.[43]

Organizational deficiencies also hampered the use of ECM. Bomber Command eventually augmented its operational planning section with the ECM officers who had previously been assigned to the communications-electronics staff. The postwar report noted that "ECM, to be most effective, must be integrated into operational

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[42]FEAF ECM Study, pp. 16-18.

[43]Ibid. pp. 8-9.

planning and tactics." Air Force manuals four decades later would make the same point. Organizational weaknesses in the intelligence system also hampered the employment of ECM. The 98th Bomb Wing noted that it obtained intelligence on enemy radar from several different sources, including Bomber Command, the 91st Strategic Reconnaissance Squadron (which flew the RB-29s), 5th Air Force recon units, and distribution by FEAF of Army, Navy and Marine Corps intelligence. The lack of a single controlling and coordinating agency meant that not only was new information on enemy radar not disseminated as rapidly as possible, but in some cases may not have been passed along at all.[44]

An additional factor which negatively influenced ECM employment was the restrictive policy in effect for most of the war. The prohibition on the use of chaff until September 1952, and the prohibition on most forms of voice jamming, which remained in effect throughout the war, were a result of Air Force fears of revealing anything which might be useful to Soviet homeland air defenses. Given the prevailing opinion that the conflict in Korea was only a precurser to a larger and more intense struggle in Europe, SAC was unwilling to expose in Korea EW capabilities and tactics which might well be needed if the Emergency War Plan was executed and SAC bombers had to carry out an atomic strike on the USSR. At first

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[44]Ibid., pp. 7, 24; 98th Bomb Wing historical report, March 1953; A good example of the lack of intelligence coordination appeared in a 5th Air Force letter to one of its units, the 3rd Bomb Wing (Light), dated 28 November 1952, which commented on "Recent reports of aircraft encountering radar controlled guns". This was five and half months after the disaster over Kwaksan, which should have convinced anyone that the enemy was indeed well equipped with radar controlled systems.

glance it might seem that little could be learned from the operations of the B-29s: it was clear to both the USAF and the Soviets, after all, that the old bombers were nearly at the end of their usefulness as front line combat aircraft. It was the equipment and procedures which SAC was unwilling to demonstrate to the Soviets. The Soviets had little knowledge of the newer jammers (such as the APT-9 and -16) and the newest forms of chaff, and using them in Korea would enable the Soviets to gain firsthand knowledge of their potential. The same held true of tactics and procedures, such as cell formation, ECM escort tactics, frequency coverages, etc. If the day ever came when SAC bombers had to carry out their primary wartime mission, they would need every advantage which ECM could provide, and it was wise for SAC to protect this advantage by not "tipping its hand" in Korea.[45]

Both the Americans and Soviets used Korea as a form of laboratory. testing equipment and procedures under the stress of combat, and both sides learned valuable lessons about their own and the other side's electronic capabilities. The Soviets learned that although the combination of radar-controlled searchlights, early warning and GCI radars, and jet fighters which they deployed in Korea could sometimes offer effective opposition to Bomber Command's B-29s, all too often the bombers were able to negate the Soviet defenses. This was hardly a confidence-building realization, for they knew all too well that the next generation of American bombers would be faster and far more capable. If their defenses could not

[45]98th Bomb Wing historical report, March 1953; FEAF Bomber Command historical report, July-December 1953, K713.01-36, in AFHRA.

stop B-29s, how would they be able to defend the motherland against large numbers of jet propelled B-47s and B-52s? The Americans, too, obtained valuable information. They learned that their prewar arrogance and confidence in the technological backwardness of the USSR was in some cases misplaced. The MIG-15 and Token radar, for example, were the equal of anything produced in the West.[46]

The Air Force learned even more from the Korean War, however, than simple lessons about equipment or personnel. The official USAF history of the war admitted that Air Force personnel "had forgotten much of what they had learned...about ECM." The Air Force had to educate, or in many cases reeducate, commanders, staffs and crewmembers about ECM and what it could do to protect aircraft and crews. It took FEAF two years, for example, to remove one organizational roadblock to improved effectiveness and move the ECM officer from Communications-Electronics (a support agency) to Combat Plans. Here was where the Air Force felt the impact of the failure to document and codify the lessons of World War II. The lack of an institutional mechanism for gathering lessons, assessing the potential of new technology, and developing doctrine to apply those lessons and technology meant that the Air Force would have to relearn them again in Korea.[47] This was highlighted by a FEAF "Report on the Korean War", which noted

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[46]Kilmarx, A History of Soviet Air Power, p. 240

[47]Futrell, USAF in Korea,, pp. 330, 572, FEAF ECM Study, pp. 23-24; FEAF, Deputy Commander for Operations/Combat Operations Division, "Report on the Korean War, 25 June 1950 - 27 July 1953" p. 52, 15 February 1954, K720.04D, in AFHRA.

in a searching and honest self-evaluation:

> "An astounding facet of the Korean War was the number of old lessons that had to be **relearned** [emphasis in original]. Personnel, from the very highest staff officer to the lowest supervisor in the smallest unit, sometimes demonstrated a profound lack of knowledge of basic procedures and techniques learned in past operations and conflicts. We must conclude that these lessons were ignored, forgotten, couldn't be located, or were never documented -- or if documented, were never disseminated. [48]

The Air Force had learned some valuable information about EW in the half-decade between World War II and the start of the Korean War, but much of it was belated awareness. For the most part, the Air Force did not use those five years to build on the lessons and capability of World War II, but instead allowed its electronic strength to atrophy. There were a number of reasons for this, some budgetary, some organizational, some because of complacency, and some attitudinal. No matter what the cause, the end result was the same: the Air Force had to relearn about Electronic Warfare, and it had to pay for those lessons in the same currency which all military forces must use to relearn forgotten lessons: reduced mission effectiveness, damaged and destroyed equipment, and the lives of brave men.

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[48] Ibid., p. 135.

CHAPTER SEVEN

CHARTING A COURSE: DEVELOPING EW POLICY AND DOCTRINE

The Air Force followed an evolutionary path in the development of policy and guidance for its Electronic Warfare program during the early 1950s. This process was subject to many different influences: the Joint Chiefs of Staff (JCS) played a role in shaping it, as did several civilian and Air Force agencies. The USAF Scientific Advisory Board played a key role in correcting one of the greatest weaknesses in the EW program, the inability to respond quickly to new equipment requirements, and helped establish a course for R&D for the rest of the decade. The lack of a controlling body, however, meant the efforts and recommendations of these various bodies were, perhaps inevitably, disjointed and uncoordinated. This chapter will examine the efforts of these different bodies, then turn to the issue of EW and Air Force doctrine. Since EW was part of the Communications-Electronics (C-E) functional area, the first attempts at developing EW doctrine were made by elements of the C-E community. At the Air Command and Staff School (ACSS, now called the Air Command and Staff College, or ACSC) for example, EW was taught by the C-E portion of the faculty. The first formal codifications of Air Force basic doctrine failed even to hint at EW, although by the mid-1950s there was a growing body of EW doctrine within the Air Force's two major combat commands, SAC and TAC, and was a significant aspect of several operational requirements. The previous chapter explored the combat use of EW during the Korean War; this chapter will backtrack to the late 1940s, to pick up the story of EW policy and doctrine and carry it forward to the culminating point, SAC and TAC in the mid-1950s.

The JCS and EW Policy

The role of the JCS in developing EW policy was established during World War II, but several other agencies also played significant roles in this process. The premier American agency was the Joint Communications Board (JCB), which included officers from all the Services and was in turn the source for representation on the Combined Communications Board (CCB), which included British officers as well. Both boards, in turn, had Radio Countermeasures (RCM) Committees, which focused on the research and development process for new equipment and on employment policy for use in combat.[1] Although the CCB was eventually disbanded after the war, the JCB and later the Joint Communications-Electronics Committee (JCEC) continued to act as the JCS oversight element for C-E activities and was the JCS' means of influencing overall EW policy. The JCEC was composed of senior officers from the Services' communications organizations, which for the Air Force was the Director of Communications. Throughout 1946, while the Services endured the chaos of demobilization, the JCB attempted to formulate an EW policy. In January 1947 the JCB forwarded a draft "Joint Electronic Countermeasures Policy" to the JCS, which in turn approved and published it on 6 March 1947. JCS Memorandum of Policy (MOP) 35, as it was called, was issued partly because the existing policy dated back to 1943 and a new one, applicable solely to US forces, was needed. It called for a "vigorous" peacetime ECM program which included: an

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[1]HQ USAF, Director of Communications-Electronics pamphlet, "RCM", (undated, but certainly pre-1950), in 143.501M, AFHRA.

aggressive electronic intelligence (ELINT) effort; an improved and extended R&D program for EW equipment; frequent tests and exercises of equipment and procedures; and in the event of war, an ability to deny the enemy the use of the electromagnetic spectrum. Taken collectively, these were very aggressive and ambitious goals. MOP 35 included a caveat concerning the danger to communications intelligence posed by the use of countermeasures, but in general it advocated a more widespread use of ECM.[2]

The policies MOP 35 established were augmented in 1953, when the JCS published MOP 85, "Policy for Delineation of Service Responsibilities for Electronic Countermeasures". This document did not change the general policy guidelines established by MOP 35, but rather clarified what "slices" of the "EW pie" would belong to each Service. It was, in short, an effort to prevent, or at least mitigate, interservice rivalry. The Army and Air Force, for example, wrangled over who should develop ECM devices used for air defense. In another case, which took place just a few weeks after the end of the war, the Joint Countermeasures Committee of the Joint Communications Board (JCB) recommended forming a Joint Countermeasures Board, which would have been a higher-level organization than the

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[2]Secretary of Defense Annual Report, 1948, p. 77; Joint Communications Board (JCB) 6013, "Joint Radio Countermeasures Policy", 10 April 1946; Joint Chiefs of Staff (JCS) 222/3, "Joint Countermeasures Policy", 26 September 1946; JCB 60/6, "Joint Electronic Countermeasures Policy", Note to the Secretaries of War and Navy, 10 January 1947; JCS 222/5, "JCS Memorandum of Policy 35: Joint Electronic Countermeasures Policy", 6 March 1947; all in Record Group 218, JCS, File 311, Combined Chiefs of Staff, Section 6, in Modern Military Records Branch, National Archives Records Service, Washington, DC (hereafter cited as NARS).

committee, but it was blocked by the Navy, evidently because the Chief of Naval Communications wanted to insure total control of the development of Navy countermeasures remained in Navy hands.[3] MOP 85 applied primarily to the development of active ECM devices (those that actually emitted signals) and did not establish guidance for the operational employment of ECM, for which MOP 35 remained the governing directive. These two Memorandums of Policy would remain the current JCS guidance on EW until both were rescinded and consolidated in a new document, MOP 95, on 16 May 1957, which in turn remained JCS policy until early 1990.[4] At the same time the JCS was establishing these policies for all the Services, the Air Force was also active in trying to chart a course for its EW program.

Air Force EW Policy

During World War II the Air Force did not have an Electronic Warfare "policy": no single guidance document existed which defined and outlined peacetime and wartime objectives. The publication of MOP 35 in 1947, however, essentially filled that role, and in February 1948 the Air Force reprinted it and sent copies to all major commands as an expression of Air Force guidance. The lion's share of the copies went to SAC, which at that time had the only operational EW capability in the Air

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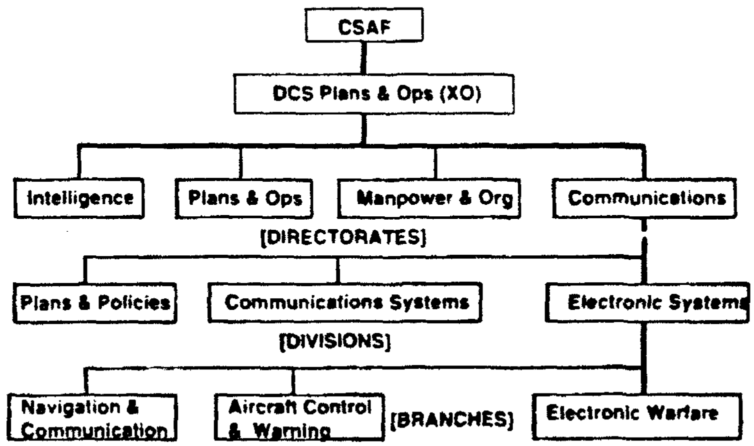
[3] Miscellaneous Joint Communications Board papers, 178.25-11, in AFHRA.

[4] JCS MOP 85, "Policy for Delineation of Service Responsibilities for Electronic Countermeasures", 12 February 1953; JCS 222/32, Chief of Staff Air Force Memo to JCS on "General Delineation of Service Responsibilities for the Employment of Electronic Countermeasures", 16 January 1953, in RG 218, File 311, Section 9, NARS; Historical Report, USAF Director of C-E, in K143.01, January-June 1956, Volume V, AFHRA.

Force. SAC later published its own guidance in SAC Regulation 55-4, "SAC Electronic Combat Policy", based in large measure on the contents of MOP 35. Yet even after the start of the Korean War, nowhere could one find a definitive statement of Air Force policy on EW.[5]

The lack of an Air Force-wide EW policy was rooted in an organizational weakness: no agency was charged with overall responsibility for EW. One focal point for Air Force EW matters was the Electronic Warfare branch of the Air Force Directorate of Communications-Electronics, but as noted previously that branch was buried within an agency that thought of electronics as an adjunct of communications. The Director of Communications was a major general, while the chief of the EW branch was only a lieutenant colonel. The following figure depicts the organization in early 1951:

Figure 7
EW in the Air Staff



[5]Letter, Department of the Air Force to Commanding Generals, Major Air Commands, subject: "Joint Electronic Countermeasures Policy", 10 February 1948, in "Development of SAC ECM Program", and pp. 24, 65 of study.

One of the EW Branch's primary functions was "close liaison with electronic warfare development, procurement, and intelligence activities" throughout the Air Force. The key word was "liaison", which is weak in an organizational sense. It implied that the branch had a coordinating and consultative role, not a controlling one. This is in stark contrast with the Air Force in the 1990s, which included a Secretary of the Air Force directorate (SAF/AQR), headed by a general officer, specifically charged with the responsibility for overseeing the development and procurement of EW equipment; and a Plans and Operations deputate (AF/XOOE), headed by a colonel, that was the focal point for operational EW matters such as doctrine. Regardless of the qualifications and capabilities of the personnel in the EW Branch, their placement so far down the C-E chain organizationally handicapped their efforts to develop fully the Air Force's EW capabilities.[6]

It would be easy to overlook the impact this organizational arrangement had on EW's position in the Air Force. Since C-E had only a collateral influence on Air Force plans and operations, there was no formalized mechanism that enabled or insured "lessons learned" or after action reports were sent to the operations community or the doctrine developers. At Keesler AFB, the Air Force's electronics training center, the staff was dominated by communicators who had no knowledge of combat operations or Air Force doctrine. The C-E community was concerned

[6]HQ USAF/Comptroller, "Organization and Functions, HQ USAF", 1 February 1951, K142.204; Historical Report, Director C-E, EW Branch, K143.01, July-December 1951, in AFHRA.

primarily with equipment, while the operations community was concerned primarily with the use of ECM to facilitate combat operations. These were not necessarily mutually exclusive objectives, and the key EW personnel at the Air Staff and elsewhere worked hard to bridge the gap created by the organization, but it was a roadblock that was detrimental to making the most of the Air Force's existing EW capability. The EW Branch was the central point of contact within the Air Force for EW matters, and as a result was involved in the development of plans and policies which involved either equipment or operations. It was because of this that SAC took pains to insure that one of its EW experts was assigned to the branch throughout the 1950s. Starting with Captain Les Manbeck (who arrived at the Pentagon only to find himself working on the very equipment requirements he had previously submitted from SAC) and later Captain Frank Lindberg, the presence of these officers insured that someone experienced in the plans and policies of SAC and its operational doctrine for bombers and their equipment would be available to work these issues at the air staff.[7]

Although the EW Branch was hard pressed working a series of key equipment issues during this period, it finally succeeded in January 1953 in publishing an Air Force Electronic Countermeasures Policy. This action was initiated in February 1952 when the Air Force Council, a board of senior Air Force generals that met periodically to discuss issues currently facing the Air Force, reviewed the status of

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[7]Lester Manbeck personal letter to author, 31 March 1989; Frank Lindberg telephone interview with author, 3 June 1989.

the Air Force ECM program. The impetus for this review is unclear, although it is unlikely that the Council raised the issue on its own, and it may have come from within the Air Staff (perhaps the Directorate of Communications). It is quite possible that the Council explored this topic at the request of SAC, which was leading the Air Force effort to improve its EW capability. The Council issued a highly critical memorandum to the generals in charge of the five principal air staff deputates (the Deputy Chiefs of Staff for Operations, Materiel, Personnel, Comptroller, and Development) highlighting the weaknesses in the existing program. Current ECM capability was "nil in TAC and ADC and marginal in SAC", in the Council's opinion, possibly because the combat commands, with the exception of SAC, had not formulated what EW operational capabilities they needed. Research and development projects were of a long-term nature and thus not geared to immediate operational needs. As a result, the time it took to react to new intelligence on enemy radar capabilities was too long and unduly protracted. Even Personnel did not escape unscathed, for the Council noted that while the technical training program for ECM personnel was lengthy it was proving difficult to retain graduates; no firm overall numerical requirement for ECM personnel even existed. No effective solution was visible for the problem of the B-47, which had no ECM capability. Finally, the Air Force had a very limited ELINT-gathering capability, with RB-50s the only ferret aircraft operational. The Council had pinpointed several key weaknesses in the Air Force's overall EW program.[8]

The Air Force Council directed the Air Staff to publish a statement outlining the Air Force policy on ECM, to insure the proper emphasis and coordination for the service's EW program. The EW Branch submitted a recommended statement of policy to the Council, which was approved by the Chief of Staff in December 1952 and expanded the next month as the Air Force Electronic Countermeasures Policy. The policy was brief, based on the contents of JCS MOP 35. One of the Air Force Council's key recommendations had been against splitting ECM into narrow, overly-compartmented areas, instead keeping it as broad and dynamic as possible to prevent unnecessary restrictions from delaying the R&D process. The new Air Force policy assigned specific responsibilities to individual major commands, so that the Air Research and Development Command (ARDC) had responsibility for developing and testing new equipment, SAC had responsibility for employment in strategic operations, TAC for battlefield operations such as close air support, etc. The value of such a policy was that it provided detail and overall direction to the Air Force's growing EW program, a program that was beginning to make major advances.[9]

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[8]Memorandum, Air Force Council, Subject: "USAF Program for Electronic Counter Measures (ECM)", 18 March 1952, in RG 341, Chief of Staff USAF, File 18, Box 21, NARS.

[9]Ibid; Historical Reports, EW Branch, K143.01, July-December 1952, January-June 1953, in AFHRA; Memorandum, Air Force Council, Subject: "Broad USAF Policy on Electronic Countermeasures (ECM)", 23 December 1952, in RG 341: File 19, Box 23, NARS; Historical Report, Wright Air Development Center, K243.011, January-June 1952, Volume II, pp. 311, and "USAF R&D Quarterly Review", 3rd Quarter, FY 1952, K243. 1251, in AFHRA.

The Scientific Advisory Board

Not surprisingly, several agencies staffed primarily or entirely by civilian experts played critical roles in shaping the Air Force EW program at the same time that the JCS and Air Force were developing policy and issuing guidance. The National Security Act of 1947 created the Research and Development Board (RDB), whose Panel on Electronic Countermeasures (part of the larger Electronics Committee) made several important recommendations in its 1949 report. It noted that current equipment for radar direction-finding (DF) was poor, and that the Services needed a more responsive direction-finding capability; hopefully, an instantaneous capability could be developed. Current jamming transmitters were all of wartime production and suffered from severe limitations as to frequency coverage and the strength of the jamming signal. Work on new transmitters was hampered by the state of vacuum tube development. The panel also noted that although existing chaff types covered a sufficiently broad frequency range, work was needed on chaff dispensing systems, especially for high speed aircraft. A radar homing receiver was also needed, and despite the "woeful" condition of existing equipment only a small amount of effort was being expended in this area. The panel called for the development of an integrated intercept system, capable of simultaneous receipt, analysis, DF, and recording of signals. It even called for a comprehensive tactical test of current countermeasures techniques and equipment that would examine ECM in an integrated weapon system setting rather than as an isolated piece of equipment.. This may have been the genesis of the Tactical Evaluation conducted by SAC and

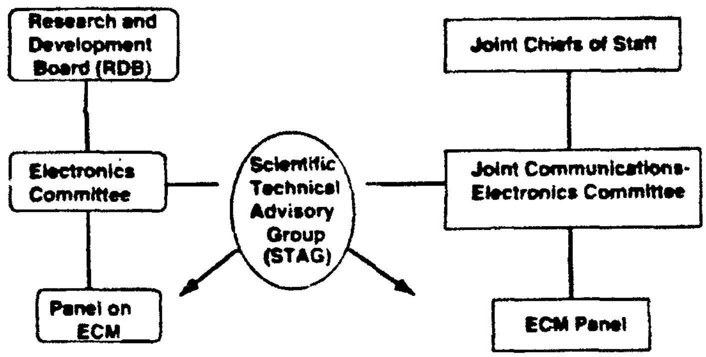
APGC in 1950 and discussed in a previous chapter.[10]

In February 1950, members of the Joint Communication-Electronics Committee (JCEC) ECM panel were invited by their counterparts on the Research and Development Board's ECM panel to attend its meetings. This was the start of closer coordination between the two bodies, which made technical recommendations on R&D matters. At about the same time, Major General N.M. McClelland, the Director of Air Force Communications-Electronics, met with several civilian scientists who had been members of the countermeasures group during World War II (Division 15 of the National Defense Research Council, or NDRC, mentioned in chapter two), who agreed to form what became the Scientific Technical Advisory Group (STAG). The STAG met with the JCEC in August and October 1950, and in January 1951 the Chairman of the RDB recommended that the two electronics committees of the RDB and JCEC jointly sponsor the STAG, which would provide expert technical assistance to the two committees' countermeasures panels.[11]

[10]Joint Research & Development Board report on Electronics, 160.8233-1, 10 February 1949; Joint R&D Board Committee on Electronics, "Annual Report on Electronics Research & Development", 160.8233-21, 1949; in AFHRA.

[11]Memo, Joint R&D Board, Committee on Electronics to Joint Communications and Electronics Committee, Panel on Countermeasures, 19 June 1950; Memo, General McClelland, Director of USAF Communications-Electronics. to Joint Chiefs of Staff, Subject: "Special Technical Advisory Group (STAG) on Electronic Countermeasures (ECM)", 31 January 1951; RG 341, File 10, Box 13, NARS. The subject of how much influence ad hoc bodies such as the STAG exercised over the overall Air Force R&D process is still awaiting a solid research study.

Figure 8
Scientific Technical Advisory Group



While the RDB and JCEC were not Air Force agencies, the Scientific Advisory Board (SAB) was. Formed shortly after the end of the war, and chaired by Dr. von Karman from its inception in 1946 until the end of 1954, the SAB focused on the Air Force's entire R&D program, not only EW. In January 1952, the SAB met at the USAF Missile Test Center (Patrick AFB, Florida) to discuss long-range R&D plans. The Electronics and Communications Panel was asked as a part of this effort to study the Air Force ECM program, which led to the formation of an ad hoc panel on ECM, chaired by Dr. Ernest Pollard of Yale University. The panel not only included five other members of the SAB, but also Dr. Fred Terman of Stanford University, who had been the head of the Radio Research Lab, also known as NDRC Division 15, and had directed American R&D in countermeasures during the war. To call him one of the country's leading EW experts would be an understatement. The panel's task was to evaluate the progress of the current ECM program and recommend any basic changes necessary.[12]

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[12]Thomas A. Sturm, The USAF Scientific Advisory Board: its First Twenty years, 1944-1964, (Washington, DC: USAF Historical Division, 1967), pp. 155-157; Executive

Six months later, while the electronic battles in Korea were approaching their zenith, the panel met in Washington to receive a series of briefings and presentations from various AF organizations concerned with the ECM program and the technical development of ECM equipment. Operational considerations of the Strategic, Tactical, and Air Defense Commands were presented by officers from those commands, while another officer briefed the members on the AF ELINT-gathering effort.[13] The programmatic emphasis of the meeting, however, was evidenced by the fact that no less than eight presentations were made by representatives of the requirements/R&D community.[14] The SAC Director of Communications-Electronics, Colonel Joe Bestic (who would later attain two stars), outlined the concerns and needs of SAC, which focused on what could be done immediately to improve SAC's EW capability. He told panel members that General LeMay considered ECM as important as armament to the survivability of SAC bombers. This was especially true of SAC's new bomber, the all-jet B-47, which would depend almost solely on speed and ECM for its defensive armament. Bestic also expressed concern over the number of organizations making ECM policy decisions, citing no less than eight

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Secretary, USAF SAB to Air Historical Office, K168.151, 13 July 1953, in AFHRA; Summary of Briefings to USAF SAB ad hoc ECM Committee, 25 July 1952, in RG 341, File 10, Box 13, NARS.

[13]It is perhaps enlightening in a bureaucratic sense that SAC sent the head of its entire C-E Division, a full colonel who eventually attained two stars, while TAC sent a branch chief who was only a major!

[14]Summary of Briefings to USAF SAB ad hoc ECM Committee, 25 July 1952, in RG 341, File 10, Box 13, NARS.

panels or committees involved in shaping ECM policy. Finally, he briefed the members on the mission of the 376th Bomb Wing, a SAC bomber unit which had been assigned the task of developing ECM tactics and providing a force of ECM escorts in the war plan. (The next chapter will cover the 376th in more detail.) The TAC representative, Major Walter Stachura, head of the ECM section at HQ TAC, stated that TAC needed a radar homing device, and he outlined equipment requirements for future TAC systems, which included unattended jammers, chaff dispensers, and a self-protection capability. He also mentioned the status of the TAC ECM program, which suffered not only from its relatively low priority in the overall AF ECM program, but also from being lightly regarded within TAC itself. Dr. Pollard's summary of Stachura's presentation is worth quoting: "A considerable body of opinion in TAC does not feel concern over radar at all and so the drive for ECM is not so insistent. This may well change."[15] It was unfortunate, both for TAC and the Air Force, that it took until the mid-1960s and the sudden realization that North Vietnamese radar-guided SAMs were causing heavy losses to American aircraft for this attitude to begin to change. This long delay is clear evidence that the Air Force had not yet solved the problem of keeping its doctrine fully abreast of technological advances, an institutional failure that would cost the Air Force dearly in Southeast Asia.

The panel members next heard presentations from several officers and scientists

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[15]Ibid; Historical Report, USAF C-E Division, EW Branch, July-December 1952, K143.01, in AFHRA.

on the course of the ECM equipment program. They noted that AF funding of the ECM program had risen from a paltry $400,000 in 1947 to $36.4 million in fiscal year 1953. The Director of Requirements at HQ USAF prioritized equipment needs as: 1) a broad-band radar warning receiver; 2) a radar homing device which could be installed on fighter-bombers to provide a hunter-killer capability; 3) an unattended jammer. These priorities closely reflected the interests and desires of the operational commands (SAC and TAC), as will be seen in the next two chapters. In fact, several different types of jammers were discussed, including barrage and repeater jammers, and the concept of putting a manned ECM pod or capsule in the B-47 bomb bay was mentioned as a means of providing a true ECM escort capability for the SAC bomber force (see Chapter 8 for a fuller discussion of the "Blue Cradle" project). Chaff was cited as the "most reliable and effective countermeasure", and external chaff pods for fighter-bombers were suggested as a means to protect those aircraft which did not have an internal chaff dispensing capability. Several speakers mentioned the need for a central activity to correlate ECM information and provide direction to the overall program.[16]

Major Robert Perry, one of the Air Force's original ECM experts, represented the Air Research and Development Command (ARDC) at the meeting and made several penetrating observations. He noted that although fully qualified officers of appropriate rank (lieutenant colonel, in his opinion) were needed for staff positions

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[16]Summary of Briefings to USAF SAB ad hoc ECM Committee, 25 July 1952, in RG 341, File 10, Box 13, NARS.

within several Air Force commands and headquarters, it was unlikely that even half a dozen such officers were available throughout the Air Force. The cause of this was the unfortunate placement of ECM officers within the Communications-Electronics career field, which shut most of them off from promotions and advancement if they remained ECM specialists. A contributing factor was the concentration of so many experienced ECM officers in one command, SAC. This was not a criticism of SAC: indeed, SAC was commended for having the foresight to establish an outstanding ECM program. It was more of an observation that the rest of the Air Force had far too few experienced ECM officers in staff positions, and there was no easy or quick way to obtain them.[17]

Perry made another observation, one echoed by nearly every participant at the meeting: the Air Force definitely needed a means of quickly producing ECM equipment. The existing system was universally condemned as being far too cumbersome and time consuming. The process of establishing a formal requirement for a piece of equipment, drafting a proposal, getting funds authorized, developing and testing and finally deploying the equipment, took up to five years, which was far too long. Since ECM was somewhat of a reactive process, in that equipment was often developed after the discovery of a specific radar for the ECM to counteract, a long R&D period meant that the target radar could operate for months or even years with impunity. Agreeing with Colonel Bestic's comments on the large number of

[17]Ibid.

organizations involved in EW, Perry listed ten different groups, agencies or committees, some Air Force, some Joint, which attempted to "expedite" the R&D process. The result, not surprisingly, was a manifestation of the bureaucratic principle "too many cooks spoil the broth" and further delays in the EW program.[18]

In October, Dr. Pollard summarised what he felt were the major points raised throughout the three-day meeting, and the one issue referenced by almost every participant was the need for some form of quick reaction capability to produce ECM equipment. Pollard also listed some reasons why he felt the Air Force was incapable of reacting quickly to enemy radar developments. First, the Air Force needed a completely integrated group of technical experts who could evaluate all the critical aspects of a situation. Second, it needed a lab dedicated to the operational and intelligence communities which could further explore ECM problems. Finally, there was no way to assemble a few units rapidly for field use or to train people to employ those units. The SAB's collective opinion of the Air Force EW program was not favorable: its executive officer, Lieutenant Colonel Peter Schenk, stated that although the operations and production communities were in good shape the R&D effort had "only shoe clerks" in the business, and that "the ECM gear the AF now has stinks." Pollard was anxious to discuss his view of the situation with General Jimmy Doolittle, leader of the famous 1942 raid on Tokyo and Vice Chairman of the SAB,

[18]Ibid.

and on 10 November 1952 they met in New York City.[19]

Doolittle's executive officer, Lieutenant Colonel Schenk, cautioned him before the meeting not to vest too much power in Pollard's hands. Although Pollard was widely and justifiably regarded as an expert in ECM and was deeply concerned about the state of the EW program, his energy and imagination were so tremendous that Schenk felt he could not be given a "blank check". Lieutenant Colonel Schenk felt Pollard could best serve as the intellectual power behind an Air Force-controlled quick reacting lab. This was the crux of the matter: Doolittle's staff warned him that Pollard was expected to recommend a tri-service set-up along the lines of the wartime Office of Scientific Research and Development, but the Air Force was loath to lose control of its EW program. During the meeting, however, Pollard agreed with Doolittle that the Air Force's ECM problem could best be solved by unilateral Air Force action, and they agreed to establish an ECM laboratory that could react quickly to new requirements. Pollard also agreed to head an "intellectual board of directors", to direct the lab's technical activities and advise the Air Force R&D community on the overall EW program. In January 1954 the Air Force published Air Force Regulation 80-32, "Quick Reaction Capability" (QRC), which formalized procedures and established a facility for the program, thus bringing to fruition the

[19]Ibid.; Prior to assuming his position as the SAB's executive officer, Schenk had served in a variety of technical and staff positions associated with air defense and electronics, including two assignments in the Requirements and Development directorates at the Air Staff.

principal recommendation of Dr. Pollard's Ad Hoc committee.[20] Although the QRC program would yield its greatest benefits later in the 1950s and 1960s, it owed its existence to the work of the SAB.

EW and Air Force Doctrine

The status of EW in Air Force doctrine during this period must be discussed at three separate levels, basic, operational, and tactical doctrine. Current (1990s) basic aerospace doctrine, as codified by AFM 1-1, clearly recognizes the criticality of EW and ECM to successful Air Force operations and classifies Electronic Combat (EC) as an "enhancement mission" that improves the Air Force's capability to perform most of its other operational missions. Such was not the case for the earliest basic doctrine manuals, however: any mention of electronics, specifically EW, was notable only by its absence. The Air Force's first attempt to produce a basic doctrine was made by the Air University, which published Air University Manual No. 1 in October 1951. Although its rejection by the Air Staff was not related to its lack of coverage of EW, it remains true that it did not even hint at the existence of EW or the need to control the electromagnetic spectrum in order to wage modern aerial warfare. The first versions of the Air Force's official basic doctrine manual, AFM 1-2, "USAF Basic Doctrine", also failed to note the importance of EW. The April

[20]Correspondence between Schenk and Doolittle, 5, 18 and 19 November, 1952, in RG 341, File 10, Box 13, NARS; in one draft memo Schenk described Dr. Pollard to General Doolittle as "a wild man", but he withdrew it and sent a softer one instead; also Historical Report, USAF C-E Division, EW Branch, K143.01, January-June 1953, in AFHRA.

1955 edition, for example, contained a paragraph on the "penetrative ability" of air forces, and cited the height and speed at which aircraft were able to fly as key elements of this capability, but it ignored the ability of ECM to cut a hole in the enemy's air defenses and assist successful penetration to a radar-defended target. Not until the 1960s and the bitter lessons of the air war over North Vietnam, when the need to somehow suppress North Vietnamese radar-guided surface-to-air (SAM) missile defenses reached crisis proportions, did Electronic Warfare make its way into Air Force basic doctrine.[21]

It was at the next doctrinal level, operational doctrine, that EW first became a factor. Since EW was an element of the Communications-Electronics field, it was perhaps logical that the first doctrinal study of EW was done under C-E auspices, an effort that predated even the first attempts to develop basic doctrine. In 1948, for example, the basic guidance for Air Force communicators, Air Force Regulation 100-1, "Air Force Communication Principles", noted the need for "provision and operation of a system of radiation countermeasures adequate to render impotent enemy radiating devices and systems." It is worth noting, however, that EW received only one paragraph in a document that devoted the remainder of its four pages to issues involving communications, perhaps revealing the relative importance accorded EW within the C-E field. Obviously, AFR 100-1 did not go far enough:

[21]Air University Manual 1, October 1951; AFM 1-2, "USAF Basic Doctrine", 1 April 1954; Air Force Manual 1-1, "Basic Aerospace Doctrine", March 1992; K168.13001-2, in AFHRA.

even before it was published, the Army Air Force Board noted the need for a separate C-E doctrine suited to the needs of airmen, not the Signal Corps. The effort languished until 1950, when the task of preparing a C-E doctrine was assigned to the C-E department of the Air Force Special Staff School at Gunter Field, Alabama.[22]

The first draft of the Communications-Electronics Instructions (CEI) was published in 1952. Comprising over fifty separate chapters, it was a welcome first step towards a C-E doctrine, and included EW as an integral aspect of the volume. There were, however, a number of problems which hampered its utility. Since it was intended for the CE community, not for operations planners, it did not reach as wide an audience as it needed to. Additionally, the CEI was not directive in nature, and although doctrine is usually suggestive rather than directive (the 1992 AFM 1-1 is a good example of this principle), this very fact limited its effect on those who were not directly involved with C-E operations. Chapter 15 of the CEI dealt with ECM, and the EW Branch at HQ USAF was still suggesting revisions to it as late as 1955.[23]

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[22]Historical Report, Air University, 239.01, July 1947-June 1948, Vol I, Part 1, pp. 52-54; "History of the Communications-Electronics Doctrinal Project Office", K239.07G-2, July-December 1959, in AFHRA; Air Force Regulation 100-1, "Air Force Communication Principles", 2 August 1948, in Air University Library.

[23]"Role of Air University in the Development of Doctrine", K239.044-4, 4 October 1965, AFHRA; Lieutenant Colonel Herbert Herman and Major Alph Westley, "The Communications-Electronics Doctrine", Air University Quarterly Review, XIII, #3 (Spring 1962), pp. 108-113. Eventually, in 1958, the CEI was rescinded and its various chapters and sections converted into Air Force Manuals, two of which (AFM 100-43 "Electronic Warfare" and AFM 100-46 "Characteristics and Use of Chaff") dealt with Electronic Warfare and ECM. Although the Air University Library has nearly all of the

The CEI were not directly concerned with combat operations: this was left to AFM 1-3, "Theater Air Operations", which constituted the heart and soul of the theater air campaign. The 1953 version of this document reflects lessons learned from the Korean War and the importance of ECM to successful combat operations. Published only a few months after the end of the war, in September 1953, AFM 1-3 noted that effective electronic reconnaissance was a "prerequsite" for an effective theater air campaign. The manual (and a 1954 revision) devoted three paragraphs to a discussion of countermeasures, noting that the nerve center of any modern air defense system was its electronic network.[24]

What AFM 1-3 failed to do, however, was to state explicitly what should have been an obvious conclusion: the enemy facilities which comprised this network, especially radar sites and control systems for radar-guided weapons, were extremely valuable targets which should be destroyed early in a counter-air campaign designed to win air supremecy in the theater of operations. Not until the publication in 1965 of AFM 2-1, "Tactical Air Operations - Counterair, Interdiction, and Close Air Support", which superceeded AFM 1-3, were electronic guidance and control, missile storage, and launch sites identified as targets. By this time, of course, the loss of American aircraft to North Vietnamese radar-guided surface-to-air missiles (SAMS)

CEI, the EW chapters could not be located: further research revealed that when the document was superceeded in the late 1950s the EW chapters were destroyed because they were classified.

[24]AFM 1-3, "Theater Air Operations", K168. 13001-3, 1 September 1953, in AFHRA.

had made abundantly clear the importance of those facilities.[25]

What made this all the more surprising, even tragic, was that a doctrine existed in 1952 which clearly identified the need to target and destroy enemy surface radar installations and radar-controlled defensive weapons. Published in November 1952 by the Tactical Air Command (TAC), the "Doctrine Governing Mission and Command Functions of ECM in Tactical Air Operations" was a remarkable document literally years ahead of its time, outlining missions for which adequate aircraft and equipment had not yet been developed. The doctrine included three types of active electronic countermeasures: jamming, deception (eg. chaff), and destruction of the enemy's electronic facilities. It called for improved ELINT capabilities, self-protection radar-warning systems for TAC aircraft, a capability to home on enemy radars and destroy them, and improved jamming systems, both airborne and ground-based. The doctrine closed strongly: "The mission of electronic countermeasures is...to prevent the enemy from making effective use of equipment or tactics employing electronics by jamming, deception, or physical destruction of his equipment."[26]

Just over two years later TAC revised and expanded this guidance with the publication of the "Tactical Air Command Electronic Warfare Doctrine", a even more

[25]AFM 2-1. "Tactical Air Operations - Counterair, Interdiction and Close Air Support", K168. 13002-1, 14 June 1965, in AFHRA.

[26]Letter, Tactical Air Command, Subject: "Doctrine Governing Mission and Command Functions of ECM in Tactical Air Operations", 19 November 1952, TAC Historical Report, K417.01, July-December 1952, Volume V, in AFHRA.

farsighted and comprehensive document than the one it replaced. Its purpose was threefold: to state basic principles guiding the operational employment of EW by TAC; to provide guidance for the orderly development of equipment, operational techniques, and tactical procedures; and to establish organizational and training requirements. Although the details of the TAC EW program will be discussed in a later chapter, this is an appropriate point at which to examine the doctrine. The doctrine called for aggressive development of ECM equipment and tactics, and it noted that an effective and superior EW program demanded "Full appreciation of the capabilities of electronic warfare by all personnel concerned with tactical air operations." In a section on basic EW concepts it cited three missions (negating enemy defenses which depend on electronics, reducing the vulnerability of friendly electronic systems, and ELINT gathering) and three tasks (electronic reconnaissance, analysis and evaluation of data, and countermeasures techniques) for EW forces. The third of these tasks, countermeasures techniques, listed in turn five specific means by which tactical air forces could counter enemy electronic systems; these included evasion, confusion reflectors (chaff), jamming, deception (chaff and/or re-radiation of enemy signals), and destruction. An addition to the doctrine was a list of potential targets, which featured radars and missile guidance systems as well as communications and navigational networks. Guidance for the conduct of ELINT gathering was greatly expanded, but of particular importance to this study were the sections concerning tactical bombing, night intruder, and fighter-bomber missions. Aircraft designated for these missions needed a variety of electronic capabilities, including radar warning systems, chaff dispensers and jamming transmitters. Of special import, as the future would make crystal clear, was an ability to home on, strike and destroy radar and other electronic sites. Although this "radar-buster" mission could be traced back to World War II, TAC's desire for the capability, and inability to attain it, would run throughout the period of this study. The doctrine's only major failure was its declaration that day fighters (pure air-to-air combat) did not need an ECM capability. Although an examination of the effect this doctrine had on the development of an EW capability for TAC shall wait until a later chapter, its very development and publication had the potential to be a major step forward for the Air Force EW program.[27]

By the mid-1950s a variety of boards and agencies were influencing the Air Force EW program, in some cases with a minimum of coordination and interaction. The JCS had published two policy guidance documents which helped shape EW for the rest of the decade, and the Air Force had established policies to guide the continued development of the EW program. The Air Force had also begun to inject EW into Air Force doctrine, although primarily at the tactical and operational levels. The Scientific Advisory Board had played the most significant role of any of the various civilian groups that were involved with EW, helping to develop a solution for one of the EW program's most glaring weaknesses, the inability to field EW equipment quickly. These different efforts were relatively disjointed, reflecting the

[27]Letter, Tactical Air Command, Subject: "Tactical Air Command Electronic Warfare Doctrine", 12 January 1955, in Air University Library.

lack of a "master plan" or controlling body for the Air Force EW program. Even so, the increased level of activity after the doldrums of demobilization reflected the rebirth of EW in the Air Force. It is worth observing that technological change and development not only occurs within an organizational and doctrinal context, it can be greatly shaped by that organization and doctrine. Was the Air Force organizationally and doctrinally prepared to exploit this rebirth? Not fully, for the positioning of EW within the C-E bureaucracy instead of plans and operations (where it is located in the 1990s) hindered rather than helped the integration of EW into all aspects of the Air Force's combat capability. Forward-looking doctrines lacked the technical capability to back up their objectives. Now that policy and doctrine have been discussed, the next step is to examine how the Air Force's two major combat commands, SAC and TAC used the first half of the 1950s to determine their requirements, field weapon systems, and hone their EW capabilities.

CHAPTER EIGHT

STRATEGIC AIR COMMAND, 1951-55: EW COMES OF AGE

By mid-1951 the ECM tactical evaluation conducted by SAC and Air Proving Ground Command (APGC) had clearly demonstrated the need for a continuing program to test equipment and develop tactics, and by 1952 SAC had expanded the effort to include an entire bomb wing. During the next three years this project would increase in scope and intent, to become a keystone of the entire SAC EW program. Hand in hand with this effort were developments in personnel, training, and exercises, to formalize the ECM operator position, finalize the process of training them to rigorous SAC standards, and test unit capability to penetrate enemy defenses and reach the target. The most visible payoff, however, was in aircraft. During the first half of the decade of the 1950s SAC developed and began deploying two radically new swept-wing jet bombers, the B-47 and the B-52, that would depend heavily on ECM as their primary means of self defense. The B-52, the first bomber ever developed with an ECM operator as an integral member of the crew, was definitive proof of just how seriously SAC felt EW would contribute to its overall combat capability.

Developing theDoctrine

By mid-1951 the ECM tactical evaluation conducted by the 2nd Bomb Wing against the range complex at Eglin AFB had clearly demonstrated that the vast majority of existing World War II-era equipment was obsolete and unsuitable for use in Emergency War Plan operations. Except for the ECM operators assigned to the test squadron (the 20th Bombardment Squadron, equipped with B-50s), most did not have sufficient experience or expertise to exploit fully even the obsolescent equipment they had. The importance of improving this situation could hardly be overemphasized. Since at least 1949 SAC unit training had increasingly concentrated on operations involving night radar bombing and long range night navigation, at the expense of activities such as formation flying. This reflected the changing SAC tactical doctrine that emphasized individual aircraft and small cell penetration of enemy defenses, a doctrine that relied heavily on ECM to negate enemy defenses based primarily on radar.[1]

One of the proposals that came out of the tactical evaluation was to form a unit that would specialize in the development of ECM tactics and their employment in combat. In December 1951 the SAC Electronic Warfare Panel recommended that a specific unit be charged with a range of EW responsibilities, including direct support of the primary wartime bombing force by jamming enemy radar defenses, conducting unit ECM evaluation during peacetime, and development of special ECM tactics and techniques.[2] The panel recommended that the 376th Bomb Wing, currently based at Forbes AFB, Kansas, be tasked with this responsibility, and the early months of 1952 saw the wheels set in motion to finalize the proposal. In early February 1952

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[1]2nd Bomb Wing history, Vol 1, May 1951, pg 8; 2nd AF history, January-July 1951, pp 94-95, K432.01; SAC Historical Study, "SAC Bombardment Training Program, 1946-59", K416.01-80, all in AFHRA.

[2]This panel was chaired by the SAC Deputy Commander for Operations, Major General Joe Montgomery, and was comprised of senior officers from several headquarters agencies including plans, operations, intelligence, materiel, and personnel.

General Power, the SAC Deputy Commander, stated that the current shortage of ECM equipment and personnel made it necessary to designate one unit whose full effort would be directed toward developing ECM tactics and techniques to support the current war plan, and also serve as a central agency for realistic testing and evaluation. General Power informed the 2nd Air Force commander that if the 376th Bomb Wing was assigned this task it would be desirable to transfer to it responsibility for supporting the SAC-APGC project on ECM tactical evaluation. Later that month 2nd AF replied that it was in complete agreement with the proposal, and outlined the detailed steps it planned to take along with the actions it felt necessary to make the project succeed.[3]

Although 2nd Air Force concurred with making the 376th Bomb Wing a specialized EW unit, many things needed to happen before the proposal could become a working reality. First, the 376th should be assigned at least the same, if not higher, priority for supplies and personnel as that assigned to those bomb wings assigned key tasks in the war plan, since the 376th would be responsible for a critical part of that mission, defense suppression. The number of ECM officers assigned to the wing should be more than doubled, while the shortage of radar mechanics

[3]Minutes of SAC EW Panel, 20 and 28 December 1951; letter, SAC Commander to 2nd AF Commander, 5 February 1952, subj: Assignment of Responsibilities to 376th BW, both in SAC Archives, Offutt AFB, NE. Because of the reorganization of the USAF that took place in 1992, which in effect deactivated both SAC and TAC and created Air Combat Command (ACC) in their place, some of the archival holdings at SAC will eventually be transferred to other locations, principally the new ACC (Langley AFB, VA), Air Mobility Command (Scott AFB, IL), or the AFHRA.

seriously limited the wing's EW capability: the armament and electronics squadron had only three partially trained radar mechanics with ECM experience, yet ninteen were needed to handle the anticipated workload. The wing's B-29s required ECM modernization and modification to equip them with not only the current ECM gear but also the new models expected to be available within two years, such as the AN/APT-6, -9, and -16, new jammers that would become SAC's second generation hardware. 2nd Air Force also requested authorization to concentrate its most experienced ECM personnel in the 376th Bomb Wing, and requested assistance from SAC in obtaining additional experienced personnel. This process was formalized in April with the publication of SAC Programming Plan 9-52, which established the wing's mission and outlined in greater detail the various aspects of the plan.[4]

The next few months were taken up with getting the 376th up to speed, both in personnel and equipment, so it could carry out its new mission. In June 1952 some thought was given to sending a portion of the wing to Korea to gain experience in combat operations with ECM, but SAC determined that the knowledge or experience to be gained there was insufficient to warrant such a move. The 376th was less well equipped with ECM gear than the B-29 units in Korea, and the enemy radars in use were so technically similar to the ones available stateside that little was to be gained by operating against them. As personnel reported throughout the summer of 1952

[4]Letter, 2nd AF Commander to SAC Commander, 18 February 1952, subj: Assignment of Responsibilities to 376th Bomb Wing: SAC Programming Plan 9-52, 25 April 1952, subj: Mission of the 376th Bomb Wing; both in SAC Archives.

the 376th Bomb Wing's capability improved, and it began testing equipment and tactics against the range at Eglin. In mid-1953 the wing's mission was significantly expanded when it was tasked to evaluate the equipment and tactics necessary to counter radar-guided surface to air missiles. While the 376th was getting started on its unique ECM mission, however, other SAC units, indeed the entire command, were also trying to improve operator and unit capability and proficiency through expanded training and exercise programs.[5]

Developing ECM Operator Proficiency: Training

One of the unpleasant facts to emerge from the ECM tactical evaluation was the direct relationship between poorly trained personnel and unreliable equipment. When the 97th Bomb Group left Biggs AFB, Texas, for England in August 1950, the list of its ECM deficiencies was long and inclusive, yet probably quite representative of the majority of SAC bomber units. Only one-third of the group's B-50s had the proper ECM antennas, and the group's lone approved chaff dispenser had been installed only hours before the group departed for England. For two years the group had only two of the four ECM officers it was authorized, and the enlisted radio-ECM operators were poorly trained. The group had only one-third of the authorized radar maintenance technicians, and their first priority was fixing radars, not jammers. The group commander felt that only about one-fourth of the regular radio operators would

[5]Memo, Chief Combat Operations Division to Director of Operations, HQ SAC, 14 June 1952, subj: Proposed Combat Training for 376th Bomb Wing, in SAC Archives, Offutt AFB, NE; 376th Bomb Wing History, November 55-March 56, in AFHRA.

become proficient as ECM operators. All in all it added up to a dismal picture of SAC's overall ECM capability.[6]

One aspect of SAC's enduring reputation for professionalism stemmed from its rigorous and realistic approach to training, and ECM was no exception. The publication in 1951 of two SAC regulations (SACR) governing ECM training (SACR 50-8, "Training", and SACR 50-25, "ECM Training for Radio Operators") established specific and rigorous standards for ECM and were an important step in correcting some of the problems highlighted by the 97th Bomb Group. SACR 50-8 set forth the training and proficiency requirements for bomber crews, including Radar Observer-ECM, an officer position, and the Radio Operator-Mechanic, an enlisted crewmember. Basic requirements in SACR 50-8 included a minimum of twelve successful jamming attempts against radars from which a report of the jamming effectiveness could be obtained. Training the radio operator-mechanic on ECM techniques and procedures, including spot jamming, was to take priority over radio operation and maintenance. The inclusion of those two positions in the regulation was a clear indication that SAC considered ECM to be an integral function of the combat crew. The provisions of SACR 50-25 were much more detailed and established several critical unit responsibilities. Each bomb wing was directed to develop a wing ECM school to train combat crew radio operators on ECM equipment and procedures. This program included both ground and flying training;

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[6]Letter, 97th Bomb Group Commander to Commanding General 3rd Air Division, 10 Aug 50, subj: ECM Effectiveness; in SACM ECM Study.

only upon satisfactory completion of the course would a radio operator be designated a "SAC combat crew radio-ECM operator". The ground phase consisted of 60 hours of instruction, including hands-on work with test gear and mockups as well as lectures, and an inflight training phase that included exposure to seven different combinations of ECM equipment. Prior to the flying phase the student had to demonstrate proficiency with approximately two dozen different pieces or variations of the jamming equipment. The ground phase had to be completed in two weeks, and after the student completed the entire program he still had to pass a proficiency check every three months.[7]

The effectiveness of wing-level training programs depended on several factors, especially the knowledge and expertise of the instructors, and the motivation of the students. Although both were problem areas in early 1951, SAC was working to correct them. As discussed previously (see Chapter Four), in late 1950 SAC transferred responsibility to Air Training Command (ATC) for the flying phase of the Air Force training program for EW officers. Although there were the usual difficulties in accomplishing the transfer, by mid-1951 the program was well underway, providing over 1000 hours of classroom instruction (36 weeks) and over 360 hours of flying training to the new EW officers.[8] In Fiscal Year 1951 this

[7]SACR 50-8 "Training", 1 July 1951; SACR 50-25 "Training: ECM Training for Radio Operators", 27 Feb 1951; both in SAC ECM Study.

[8]Not all of the 360 hours (12 weeks) were spent in the air, of course: actual flying time scheduled was 114 hours. Until 1952 this entire training course was programmed to last 240 days. In 1952 the source for students was changed to require all entrants to

training program produced about 19 students per month, but the demand was so great that in FY 1952 the rate was projected to more than double, to 50 per month. This rate was never met, however; the greatest number of EW officers produced annually during the period 1947-1955 was 308 in 1954, slightly more than two dozen per month.[9] These officers were technically proficient and well prepared to train the enlisted radio-ECM operators at SAC's various bomb wings. The motivational problem had not yet been solved, however, because these graduates of a technically-complex course were not granted aeronautical ratings upon graduation, even though they were on flying status during and after training and their primary function was as a bomber crew member. This tended to make the career field much less attractive than it should have been.[10]

SAC repeatedly addressed the status of the ECM operator within the Air Force personnel system during 1951. SAC was currently authorized one EW officer per

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be graduates of the Basic Observer Course, which shortened the length of the course to 175 days. In 1953 this was again changed, so that entrants had to be graduates of the Primary Observer Course, which further shortened the course length to 160 days. The flying portion remained the same, with 88 hours in the TC-54D trainer. Source: Air Training Command Reference Paper, "Major Changes in Electronic Warfare Officer Training, 1943-1986", by Dick. J. Burkard, ATC History and Research Office, February 1987.

[9]The figures for the decade covered by this study are: 1946-12; 1947 and 1948-none; 1949-56; 1950-59; 1951-159; 1952-249; 1953-251; 1954-308; 1955-181. Only during the six years between 1958 and 1963 would the Air Force graduate more than 308 EW officers from its training program. The figures for 1947 and 1948 are graphic proof of the impact the postwar demobilization had on the Air Force EW program. Source: Ibid.

[10]ATC History, Vol I, pg 897-899, and Vol II, pg 481-482, July 1950-June 1951, K280.01; Keesler AFB Historical Report, October-December 1951, K285.18-24; all in AFHRA.

bomb group and one per bomb squadron, but in January General Power, SAC Deputy Commander, requested changing the authorization to add one EW officer (MOS 7888) per five aircraft. This would increase the overall bomb group strength from two EW officers to five, one EW officer on the group staff, one on the squadron staff, and one in each flight of five bombers (three per squadron.) As discussed earlier, operation of the ECM equipment on most bombers was the responsibility of the radio operator, who did the ECM work as an *additional duty*. General Power recommended authorizing a full-time ECM operator for each SAC bomber. In most cases this could be accomplished in B-29 and B-50 crews, he felt, by assigning the task of operating the radio to a scanner-gunner and making the ECM-radio operator a full-time ECM position. On the huge B-36, General Power suggested, adding a full-time ECM operator position next to the current ECM-radio operator would meet the need. These actions would solve this problem, which SAC had formally identified to HQ USAF in late 1950. General Power's final recommendation concerned the ECM operator's career path. In view of the importance of the job and the level of technical expertise it required, the new crew position should be authorized a master sergeant instead of the staff sergeant authorized for radio operator. This higher rank would attract better qualified people into the field and help to retain them. The job should be assigned a new and distinctive job title and MOS to separate it from that of radio operator, and entry into the field should not carry the radio operator MOS as a prerequisite. This high-level interest was another indication of how seriously SAC considered improving its EW capability.[11]

By summer 1951 the Air Force approved General Power's recommendations, with highly beneficial results. Radio operators had understandably considered ECM to be just extra work with no reward, and thus were less than enthusiastic about it. Colonel Joe Bestic, Chief of the SAC Communications-Electronics Division and an EW pioneer, noted the result in a memo to the SAC senior staff: "(the) response of radio operators has been instantaneous. Everybody wants to improve when there is a promotion in sight for the effort expended. This accounts in part for the recent approximate doubling of the countermeasures effectiveness of aircrews."[12] A new Air Force Specialty Code (AFSC 27371, the successor to the Army's MOS) was created for the ECM operator, and it offered advancement to the grade of master sergeant, a significant improvement over the highest grade attainable as a radio operator, which was staff sergeant. An added factor was the SAC Lead Crew system, which offered spot promotions for those crews good enough to attain Lead Crew status. Since the ECM operator's proficiency was also evaluated as part of the crew's overall proficiency, the ECM operator also had to demonstrate top notch capability, which added additional incentive to his need to improve his proficiency.

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[11]Letter, SAC Deputy Commander to HQ USAF, Director of Military Personnel, 10 January 1951, subj: ECM Crew Members for SAC Bombardment Aircraft; in SAC ECM Study.

[12]Memo, SAC Director of Communication-Electronics Division to SAC Commander, Deputy Commander, Chief of Staff and Deputy Commander for Operations, 18 May 1951, subj: SAC ECM Program for Bombardment Aircraft, in SAC ECM Study.

These measures would not take effect for several months, nor would they immediately solve all of the problems SAC was experiencing with ECM operator proficiency, but it was a welcome and long-needed step.[13]

Developing Unit Proficiency: Exercises

Possibly no other military organization the size of SAC has ever attacked the task of developing and maintaining unit proficiency so vigorously as did SAC. Unit self evaluations, higher headquarters inspections, and frequent exercises were its trademark under General LeMay. This was also true of its EW capability in the early 1950s, and SAC took every opportunity to practice and hone its ability to carry out the Emergency War Plan. One of the earliest examples of this was a cooperative program between SAC and the Air Defense Command (ADC), in which SAC ECM operators were able to practice jamming against actual radars, and the ground radar operators were able to experience actual jamming and attempt to circumvent its effects. This program, known as "Big Photo", gave both commands opportunities to evaluate the proficiency of their personnel and the effectiveness of their tactics and equipment. Procedures were laid out (in SAC's case) by SACR 51-6, which established standard operating procedures for bomber units exercising against ADC installations. SAC bombers attempted to jam ground-based search and height-finding radars, and airborne-intercept radars carried by ADC fighter Functionally these

[13]Ibid; Memo, Chief, Operations Analysis Division, HQ SAC to SAC Deputy Commander for Operations, 4 June 51, subj: Change in ECM Position, in SAC ECM Study.

included virtually every type of radar that FEAF B-29s were encountering in Korea: early warning, ground controlled intercept for fighter control, and gun-and-searchlight control radars. Strict prohibitions against jamming voice communication links were enacted, however, to enhance flight safety.[14] Effectiveness criteria were developed to grade the results of each jamming effort, from no visible effect to complete saturation of the radar screen. The regulation included a list of ADC radar sites and the type of radars with which they were equipped. In some ways this system artificially favored the bomber. Since the units had some control over which ADC sites they operated against (because of location, etc) they were able to operate against certain sites more frequently. If a unit encountered a weak ADC site, because its personnel were poorly trained or its equipment unreliable, the bombers could possibly keep their scores high by frequently training against that site, lulling the ECM operators into a false sense that they could jam anyone, anytime. This was probably a relatively minor problem, however; the key point is that both SAC and ADC were able to obtain realistic training with which to verify the overall state of

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[14]This illustrates another of the often-difficult decisions that must be made between operational realism in training and the need for safety. It is obvious that jamming the fighter-GCI voice communication links would have made the training more realistic by mirroring both what the bombers could have done against enemy defenses and what enemy bombers could have done to Air Defense Command radar sites, but the concern that this procedure could lead to accidents between the fighters and the bombers, or perhaps even civilian aircraft, led to the prohibition. These decisions are made even today: witness the decision that training flights during Operation Desert Shield before the Gulf War of 1990-91 were prohibited from flying below a certain altitude, to end a rash of accidents in which airplanes "flew into" the ground during low-level training.

operator proficiency and equipment reliability and effectiveness.[15]

In several areas the initial "Big Photo" exercise results merely confirmed what both SAC and ADC already knew: equipment shortages and unreliability were perhaps the greatest obstacles to improved ECM effectiveness, although other, more mundane problems also hampered the effectiveness of the program. Communication difficulties between the bomber and ADC units sometimes led to fighter scrambles and intercepts when the bomber unit was not engaged in that type training. In other cases, ADC interceptors had to be able to read the serial number of the bomber to gain credit for a successful intercept. This led to the fighters making unrealistic intercepts and attacks in order to slow down sufficiently and get close enough to read the serial number, neither of which would happen in combat! Yet SAC was gaining experience and improving the expertise of the bomber force, even in the early months of the "Big Photo" program. One such exercise will serve as an example. During the night of 22-23 September 1951, SAC bombers carried out a series of practice strikes against targets in California defended by the Western Air Defense Force. Some bombers initiated jamming actions too soon, which merely served to provide early warning of the oncoming bombers. Other bombers were more successful, however, and by using random chaff drops and active jamming one bomber managed to avoid interception by more than a dozen fighters and

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[15]SACR 51-6, Supplement 1, 7 June 1951; "Flying Training: ECM Phase of SAC-ADC Interceptor-Bomber Training", in SAC ECM Study; Dr. George L. Montagno, "War of the Wizards", ADC Communications-Electronics Digest, October 1955, K410.902-1; all in AFHRA.

successfully penetrated to the target near Sacramento. Later that night bombers using both chaff and jamming were able to penetrate both the Los Angeles and San Francisco areas while fighters were committed against chaff clouds. The ADC after action write-up ascribed much of the difficulty to new ground radar operators who had never experienced jamming or chaff. Given the assumption that Soviet ground radar operators were probably even more unfamiliar with active jamming and chaff, it is reasonable to assume that they would have experienced even greater difficulty against SAC bombers executing real combat missions. Regardless of the individual difficulties and shortcomings exposed by these early exercises, it was obvious that ECM was a key, possibly decisive, aspect of SAC's wartime capability.[16]

A similar but even larger operation, Exercise "Check Out", was mounted against targets in the eastern seaboard area in late July 1952, and again clear lessons were learned about the effectiveness of ECM in assisting bomber penetration. Entering from north of Nova Scotia, four strike forces "attacked" Pittsburgh, Washington DC, Philadelphia and New York, with a separate bomber tasked against each of the six targets in the four target areas (24 total targets). The bombers made night cell penetrations, in accordance with the SAC tactical doctrine, while more than two dozen other bombers approached from over the Atlantic Ocean as a diversionary force. The least effective ECM tactic was active jamming, primarily due to

[16]Historical Reports by Eastern Air Defense Force, January-June 1951, K412.01; Western Air Defense Force, July-December 1951, K4111.01; ADC Communications-Electronics Newsletter, December 1951, K410.902-1, all in AFHRA.

equipment shortages. Chaff confused some ground controllers, but the most effective tactic involved jamming the VHF radio links to the fighters. It is worth recalling that the use of this tactic was prohibited in Korea because of the desire to preserve a valuable source of intelligence.[17] Exercises such as these were conducted literally hundreds of times during the early 1950s, sometimes involving many dozens of bombers and fighters and thousands of personnel. Millions of Americans slept soundly while fierce mock battles were fought high overhead, with the electronic portion of those battles being relatively less mock than the rest![18] The benefits to SAC (and ADC) were considerable, and the opportunities to refine the tactical doctrine were invaluable. Some of artificialities inherent in the "Big Photo" procedures were corrected in 1954 with a new exercise program, Project "Realistic", which permitted both SAC and ADC to operate in a more combat-oriented manner. Ground radar controllers were permitted to use the anti-jamming devices on their equipment, which not only gave them better training but also exposed the bomber

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[17]2nd AF History, July-December 1952, K432.01 in AFHRA.

[18]Page 204 of Captain Kenneth Schaffel's study The Emerging Shield: the Air Force and the Evolution of Continental Air Defense, 1945-1960 (Washington, DC: Office of Air Force History, 1991) has the following description of an air defense center during this period: "Each site consisted of a search radar, a height-finding radar, and devices for communicating with interceptor pilots. Radar operators analyzed their scopes in darkened control centers where aircraft appeared as blips on the scopes and target information was supplied by telephone from adjacent GCI sites. In major control centers, large plexiglass boards depicted the local geography, and airmen used grease pencil to mark the boards to show aircraft in the vicinity." Even this fine study, however, makes almost no mention of the SAC-ADC exercise program during the early 1950s.

ECM operators to new radar procedures and indications that they might face in combat. By allowing the ground radar operators to change radar frequencies when jammed, the airborne ECM operator had to recognize when his jamming was being avoided and thus compensate for it. Instead of the ADC operator merely recognizing that he was being jammed or the bomber ECM operator merely jamming a fixed signal, both now had to adjust and react to the other's actions. In some ways, Project "Realistic" was proof that both commands had progressed, and provided a measure of the significant improvements made in their overall EW capabilities.[19]

New Bombers: the B-47 and B-58.....the Welterweights

During the decade covered by this study, SAC developed or deployed four new bombers, the relatively small (three-man crews) B-47 and B-58, and the relatively large B-36 and B-52.[20] It is worth noting that in the nearly four decades since the close of this study, SAC developed only three bombers (B-70, B-1, and B-2), of which only the B-1 has been deployed on actual service. The B-36 and B-58 are at the opposite ends of this study and will not be covered in great detail: the B-36 was, in terms of electronic warfare, too similar to the outgoing B-29 and B-50, while the B-58 (which did not fly until 1956) is mostly beyond the bounds of this story. The B-47 and B-52 are the focal points of this section, because they illustrate the two key

[19]Western Air Defense Force History, January-June 1954, K411.01; ADC Communications-Electronics Division Newsletter, June 1954, K410.902-1, both in AFHRA.

[20]One could argue that there was nothing "relative" about the B-36: it was absolutely enormous no matter how one looked at it!

themes of SAC bomber ECM development during this period.

Even before the end of World War II, the Air Force called for the development of a bomber with a minimum speed of 500 mph, an operational altitude of 35,000 to 40,000 feet, and a range between 2,500 and 3,500 miles. The first prototype B-47 "Stratofortress" flew in December 1947, and the first production model flew on 25 June 1950, ironically the same day that North Korean troops crossed the 38th Parallel to initiate the Korean War. Manned by a three man crew (pilot, co-pilot, and bombardier/navigator), the B-47 was virtually defenseless: the first production models carried a fixed tailgun and no ECM, because it was intended to fly too high and fast to be intercepted. By October 1950, however, SAC realized that the B-47 needed an ECM capability, and General Power identified the need to provide the B-47 with an automatic jamming system; until such a device was available, however, the B-47 should be equipped with barrage jammers, even though such equipment was inadequate and provided only limited frequency coverage. He also wanted information on the B-47's vulnerability to radar, such as the range at which it could be detected and how well fire control radars could track it. This dovetailed nicely with an effort begun that same month called Project WIBAC, to determine the operational suitability of the B-47.[21]

Project WIBAC got underway rapidly, and by January 1951 the first test aircraft

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[21]Letter, SAC Deputy Commander to HQ USAF/Director of Requirements, 3 October 1950, subj: Requirement for ECM for B-47 Aircraft, in SAC ECM Study; Michael E. Brown, Flying Blind: The Politics of the U. S. Strategic Bomber Program, (Ithaca, NY: Cornell University Press, 1992), p. 95.

had arrived at Eglin AFB. In March tests were conducted to determine the vulnerability of the B-47 to ground-controlled interception by F-86 and F-94 fighters, including tests conducted at the B-47's maximum altitude, and another at its maximum speed. The results were enlightening. The F-94, which was primarily a night fighter, had only one successful intercept in seven attempts: it was too slow. The F-86, on the other hand, handled the B-47 easily. Of the 42 attempted intercepts, 36 were successful, and all 6 failures took place on the first mission, probably due to ground controller inexperience. The Air Force's faith in bomber speed had been betrayed by even greater speed by the fighters. Even before the radar detectability tests were completed it was apparent that the B-47 needed ECM to protect itself against enemy fighters: "ECM [should) be developed...as a protection from air-to-air launched missiles and the gun-laying radar of all-weather fighters."[22]

While the initial WIBAC tests were being conducted, General Power strongly restated the need to equip the B-47 with a modern, capable ECM suite. Present plans called for equipping the B-47 (B and C models) with an unattended pair of barrage jammers, the AN/APT-5 and the AN/APT-16, as an interim measure. The APT-5 was a relatively weak World War II-era jammer, while the APT-16, although it was a newer, more powerful jammer designed to cover the S-band frequency range, was still a World War II-era derivative. General Power did not mince words: because of their age and inflexibility (they had to be preset before use) the

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[22]Air Proving Ground Command History, July-December 1951, K240.01, in AFHRA; Brown, Flying Blind, pp. 95-98.

self-protection capability provided to the B-47 was "for all practical purposes negligible." Worse, the outlook for at least the near future was poor. Although the ECM protection provided the B-29, B-50 and B-36 force was improving, the coming changeover to the B-47 as SAC's primary bomber would effectively eliminate that capability. "This headquarters is extremely concerned", General Power stated, "over the lack of development of an adequate electronic protection capability for future SAC aircraft." One possibility being examined by Boeing, which manufactured the B-47, was to install a manned pod in the bomb bay. The pod could carry as many as four ECM operators and jamming equipment, giving that aircraft the capability to screen or escort other aircraft, just as the "Porcupine" or "Guardian Angel" B-29s did during the bombing offensive against Japan in 1945. The preferred solution was still an automatic jammer that could detect and jam signals, as well as dispense chaff, with a minimum of crew input. Since the ECM gear would be operated by the co-pilot it had to be "the ultimate in simplicity and reliability."[23]

General Ankenbrandt's reply to General Montgomery, the SAC Director of Operations, addressed some of the key problems facing the SAC EW program as it stood in mid-1951. Normal procurement procedures were being side-stepped to permit sole-source acquisition of limited operational quantities of equipment prior to

[23]Letter, SAC Deputy Commander to HQ USAF/Director of Requirements, 24 February 1951, subj: Requirement for Expansion of ECM Capability in B-47-type Aircraft; Letter, Brig General Montgomery to Major General Ankenbrandt, 26 April 1951, both in SAC ECM Study; Price, History of US Electronic Warfare, Vol II, pp. 137-143; data on the APT-5 and -16 can be found on pp. 324-325.

service test, which potentially eliminated months of delay in production but also increased the chances that a technical problem would not be discovered until it was too late to correct it easily. The FY 52 ECM R&D and procurement budget reflected a 600% increase over the FY 50 budget ($24 million vs $4 million). This undoubtedly was impacted heavily by the outbreak of the Korean War and fear of war in Europe. The primary new S-band Jammer, the AN/APT-16, was scheduled to go into production late in 1951, and SAC would receive the lion's share of the more than 1400 sets scheduled for production. The outlook for the automatic jammer SAC so eagerly sought, however, was not good; the technical problems were extremely complex, and a long research period was likely. Even providing the interim S-band barrage jammer was going to require a crash effort.[24] An additional problem, not mentioned by General Ankenbrandt, was highlighted by a civilian technician at the Wright Air Development Center: "When it came to installing a jammer in a plane, we usually got the most worthless bits of real estate, the ones nobody else wanted!...We got what was left when all the other systems were in; we came last."[25] This might not seem serious, but because of such factors as cable lengths and antenna position this could seriously degrade the performance of the ECM gear. This situation existed because none of the existing or planned aircraft, with the

[24] Briefing by a "SAC ECM Survey Team", undated (but likely from late 1956), M-39790 in Air University Library; Letter, Major General Ankenbrandt to Brig General Montgomery, 4 May 1951, in SAC ECM Study.

[25]Price, History of US Electronic Warfare, Vol II, p.137.

notable exception of the B-52, were designed with an EW capability in mind. EW was treated as an add-on, and received little priority during the aircraft design process.

The rest of the year was marked by virtually constant communications between the Requirements Directorate at HQ USAF, SAC, Air Materiel Command, APGC, and Boeing, regarding improvement of the B-47's ECM capability. In mid-February 1952 HQ USAF informed SAC that the concept of placing a manned ECM pod in the B-47 bomb bay was being evaluated, but that even if such a modification proved feasible it would take a minimum of four years to deliver the pods to operational units. As an interim solution, the Requirements Directorate suggested installing a chaff dispenser, radar warning receiver, and a combination of different jammers.[26] Another possible solution would be an unmanned pod, which could carry several additional jammers but would not require the same amount of complicated reengineering and redesign necessary to develop a manned pod. In April the Wright Air Development Center at Wright-Patterson AFB hosted a conference to address the B-47 ECM problem. The four-man pod concept was rejected, and Boeing was requested to examine the feasibility of a two-man pod. Not until July, however, did all the different parties come to agreement. Air Research and Development Command then authorized development of the two-man pod, stating "expeditious development of two (2) man pod was of utmost importance....ECM pod enjoys the

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[26]These included the AN/ALT-3, AN/APT-6, -9, and -16.

same overriding 1A priority as the B-47 aircraft itself."[27]

During this period the Air Force Council, a HQ USAF body comprised of senior general officers on the Air Staff, periodically addressed ECM as a problem area that required "particular attention." General LeMay told one meeting that "it was as necessary as a bombsight or the guns for each aircraft to have a chaff capability." The Council was concerned that the engineering process for the B-47 ECM suite was proceeding too slowly, and it questioned Boeing's level of interest in the project. The Council also questioned the overall Air Force level of interest in ECM as well, with the notable exception of SAC. The Tactical Air Command (TAC) in particular came in for criticism for having little interest and less capability in ECM.[28]

Justified as the criticism of TAC may have been, the criticism of Boeing was probably unfair. The historian at the Wright Air Development Center (WADC) noted that the development of the B-47's ECM capability was "characterized by a remarkable degree of confusion, contradiction, and disagreement" among several different Air Force commands, agencies, and Boeing. It took nearly two years to move from SAC's original proposal for a manned ECM pod until Boeing submitted a preliminary cost proposal for the two-man pod. This may have been because the

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[27]Letter, HQ USAF/Director of Requirements to SAC Commander, 13 February 1952, subj: B-47 ECM, in 2nd AF History, Vol I, January-June 1952,K432.01; quote from "Chronological History of B-47 ECM Correspondence and Conferences", 16 December 1952, in Wright Air Development Center History, Vol III, January-June 1953, K243.011; both in AFHRA.

[28]Minutes of Air Force Council meetings, 11 September and 11 December 1952, and 27 February 1953, in Record Group 341, File 18, Boxes 21 and 22, NARS.

project was a technical nightmare which required redesigning virtually the entire B-47 electrical system. In mid-December 1952 the Wright Air Development Center prepared an analysis of the B-47 ECM program, to state clearly the present status and future plans. The B-47 required three ECM capabilities: self-protection, escort protection (jamming pod), and electronic reconnaissance (ferret pod, not discussed here). The self-protection capability was to be acccnplished in four stages. In the first and most basic, the B-47 would be able to jam any two signals in the 300-1400 MHz frequency range via pre-set barrage jammers. By early 1953 the second phase, a chaff dispensing capability, was to be added, while phase three, to be completed by summer 1953, would increase the coverage of the pre-set barrage jammers to the 30-4104 MHz frequency range. The phase four prototype, programmed for summer 1954, would add the ability to jam voice communications, such as those used for fighter control, and install an unattended automatic S-band jammer. The prototype manned jamming pod was programmed for demonstration at the end of 1954. First production articles were not expected until at least a year after prototyping, so these dates were at least a year short of actual operational capability. Although this program proved in the event to be too ambitious, the Air Force at least seemed to have a definite schedule and series of objectives to meet.[29]

In early 1953 the Air Force acted to formalize this six-phase program. After

[29]Wright Air Development Center History, Vol II, January-June 1953, pp. 415-417, K243.0ll; "Chronological History of B-47 ECM Correspondence and Conferences", 16 December 1952, in Wright Air Development Center History, Vol III, January-June 1953, K243.011; both in AFHRA.

some urgent correspondence between General LeMay and General Laurence Craigie, Deputy Chief of Staff for Development at HQ USAF, and between Air Force Chief of Staff General Nathan Twining and Mr. William Allen, president of Boeing, the Air Research and Development Command (ARDC) hosted a meeting of SAC, Boeing, and Air Force Requirements personnel at which ARDC attempted to finalize this program. Major General Albert Boyd, the Wright Air Development Center commander, directed an "all-out effort" to solve the daunting technical problems with which the program was infused, and he told his boss, Lieutenant General Earle Partridge, ARDC commander, that "I intend to personally follow this program in order to insure adequate, complete action." General Boyd was keenly aware that his organization was being blamed in some quarters for the slow progress being made on the B-47 ECM program, and he noted that the sudden reawakening of Air Force interest in EW had led to "pressure beyond reason" for fast results. General Partridge agreed that just because the Air Force had "finally recognized" the importance of EW was no guarantee that rapid and large increases in the money and personnel devoted to it would yield immediate results. The finality of this program was cast into doubt, however, in May 1953 when a staff officer from the Directorate of Requirements observed during an inspection that "the B-47 ECM configuration is neither approved nor firm". General Boyd reacted violently to this "vacillation" at HQ USAF, observing that Boeing, which had been criticised by the Air Force Council for its apparent lack of interest in ECM (see above), would certainly not be impressed: "Knowledge by Boeing of such (Air Force) indecision cannot but undermine the pressure we have built on them." Despite the fact that this flap soon blew over and the work progressed on the six-phase program, it was indicative of the activity and confusion that marked the EW program at the time. High-level interest often yields as a by-product high-level interference: the WADC historian noted that "suggestions for major changes continued to arrive virtually with every mail delivery" throughout 1953.[30]

The uncertainty and discontinuity exhibited in the EW program did not, however, prevent progress from being made at the technical level, and 1953 saw significant advances that improved the B-47's ECM capability. The chaff dispenser was placed in the midship compartment where the rocket-assisted take-off device had previously been located, and it functioned very satisfactorily, as did several new types of chaff that not only more effectively screened the aircraft but also gave some protection from radar-guided missiles. Promising tests were conducted on a forward-firing rocket to deploy chaff in front of the airplane, where it would have a greater screening effect. In July 1954 a series of successful tests of a new sweep jammer seemed to offer promising possibilities for solving at least a small part of the B-47's ECM deficiencies. Sweep jamming, in which the jammer was rapidly retuned through a sequence of frequencies, offered the possibility of an unattended jammer covering a wide range of radar frequencies. It did not totally obscure the aircraft,

[30]ARDC History, Vol I, January-December 1953, pp. 408-411, K243.01; WADC History, Vol II, January-June 1953, pp. 418-421; Letter, Major General Albert Boyd to Lt General Partridge, 4 May 1953, subj: B-47 ECM, in Vol III, Exhibit 18, K243.011; WADC History, Vol II, July-December 1953, p. 323, K243.011; all in AFHRA.

but served rather to interrupt the signal, which might render the radar ineffective. SAC was soon scheduled to begin receiving the first of over 1,300 B-47s equipped with the phase three ECM suite, which included a chaff dispenser and two unattended sweep jammers. Work was also started on the development of radar decoys, small drones that were intentionally designed to reflect radar signals and appear like a bomber, thus distracting the defenders from the real targets.[31]

Tests of the sweep jammer concept quickly demonstrated that it was not the solution to all problems, however, and individual aircraft received only marginal protection. The slow sweep rate and limited frequency range, coupled with the jammer's tendency to drift off of the intended coverage, meant that its effectiveness could vary widely, but it was better than nothing. The manned ECM pod concept had its problems too, not the least of which concerned human factors--there was no way out of the pod if the aircraft developed problems or was damaged![32] This problem illustrated the difficulties of trying to redesign major elements of an aircraft to provide an unforseen or unplanned capability, in this case a significantly expanded EW suite. The compromise solution to these problems was an unmanned jamming pod known as the "Blue Cradle" that transformed the aircraft into a pure ECM

[31]WADC History, Vol II, July-December 1953, pp 323-325; Vol III, January-June 1953, p 325, and Vol IV, Exhibit P-3; Vol II, January-June 1955, p. 259, all K243.011 in AFHRA; Price, History of US Electronic Warfare, Vol II, pp. 140-141; Interview with Mr. Harry Smith, transcript in AOC Archives.

[32]Eventually the two-man version, which was not deployed until the late 1950s, was equipped with downward-firing ejection seats, but no one ever survived an escape attempt.

escort. This was the phase four ECM configuration for the B-47. The 376th Bomb Wing, which in wartime had the ECM escort mission and in peacetime the prime responsibility for ECM test and evaluation, was equipped with "Blue Cradle" by 1955. These EB-47s (the "E" prefix indicated its electronic mission) carried the basic three-man crew as those B-47s carrying bombs, with the co-pilot operating the jammers. Perhaps "operating" is too inclusive--all the co-pilot did was to move the "on-off" switch! Each "Blue Cradle" carried up to eight slow-sweep jammers in a variety of configurations depending on the radar frequency coverage required.[33]

Across SAC, the growing numbers of B-47s brought some not-unexpected problems in the everyday life of a bomber unit. Until sufficient numbers of jammers were available at each base the priority went to those aircraft configured "on alert" and ready for short-notice launch. At the 303rd Bomb Wing, for example, based at Davis Monthan AFB near Tucson, Arizona, the first B-47s equipped with radar warning receivers and chaff arrived in 1953, but it took three years to begin receiving jammers. Even then, the wing only had enough full ECM suites for eight aircraft. Three-fourths of those went to the alert force, which meant that the remaining jammers had to be shuttled between aircraft for training missions. The maintenance load this imposed on the wing was considerable and, when combined with the related problem of new and inexperienced maintenance personnel, often led

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[33]WADC History, Vol IV, January-June 1954, Exhibit P-3, K243.011 in AFHRA; Price, History of US Electronic Warfare, Vol II, pp. 140-141; Briefing by "SAC ECM Survey Team" undated, M-39790, in Air University Library.

to unexpected problems, some vexing, some humorous. In one incident a master sergeant who had just cross-trained into ECM from the motor pool was removing a jammer from a bomber; when his instructor (an airman first class) told him to "cut the wires" (slang for removing the connections) he took it literally. The result was an ALT-6E jammer with six cannon plugs in each side, neatly severed wires sticking out of each one! It took several hours to fix it, and the ECM shop supervisor had the entire mess mounted on the wall with a sign "This is NOT what you do to get a system out of the aircraft."[34]

Even with the problems imposed by new equipment and inexperienced personnel, SAC's capability to effectively employ ECM steadily grew during 1955. One way to illustrate this is to examine briefly a few exercise missions mounted by the 376th Bomb Wing during the year, to evaluate its capability and determine how it would use ECM in wartime. In mid-July the 376th participated in a three-day exercise called "Picket Fence", designed to evaluate the wing's ability to Jam S-band radars. Each day the wing sent approximately fifteen B-47s on a course from Memphis, across the Ohio River valley, to the northern tip of Maine, jamming ADC radars along the way. The aircraft carried ALT-6 and ALT-8 jammers preset to cover the S-band frequency range, between 2700 and 3100 MHz. Although some radar operators "were amazed at the strength of the jamming", and two of the three ADC sites were unable to track the B-47s, operators at the third site reported little

[34]Incident quoted in Price, History of US Electronic Warfare, Vol II, pp. 143-144.

difficulty in following their progress. Each of the three cells on each mission was separated by approximately 40 nautical miles, which proved to be too large of a gap. The high rate of equipment malfunctions undoubtedly also contributed to reduced effectiveness, as did personnel errors. Nearly 10% of the ALT-6 transmitters were erroneously turned off before takeoff; combined with other malfunctions, fully 15% of the ALT-6s were inoperative at the very start of the mission, and another 12% failed during flight. Even these totals, however, were favorable when compared to the other jammer, the ALT-8. When personnel and equipment errors were combined, nearly half of the 80 ALT-8s carried on this mission failed.[35]

One of the artificialities that affected ECM performance during "Picket Fence" was that there was no bomber force participating, which would have added their ECM capability to the 376th as well as complicated the tactical picture with more airplanes and targets. In mid-October 1955 many of these deficiencies were corrected in an exercise named "Send Off", in which bombers from two different wings as well as the 376th participated. Aircraft from the 2nd and 306th Bomb Wings flew from bases in the U.S., while the 376th staged from Great Britain. Weather prevented ECM use on the second and third days of the exercise, thus providing an excellent opportunity to compare the effectiveness of ECM used on the first day. Missions flown on 12 October benefitted greatly from heavy use of both jamming and chaff. The tactics and techniques were "extremely effective" against the

[35]2nd AF History, Vol VI, July-December 1955, K432.01, in AFHRA.

early warning and GCI radars operating in the S-band. Jamming and chaff "completely disrupted...GCI control and reporting systems. The ECM was so effective that radar directors could not determine the type formation, tracks or number of strike aircraft." The mechanical reliability of the force, which suffered a significantly lower percentage of jammer failures (only 9%) than during the July exercise, also increased its overall effectiveness. The combination of "Blue Cradle" and bomber jammers and chaff created a zone 250 miles wide and 300 miles deep in which ground radars were disrupted, which provided a significant measure of protection to the strike force. The combination of sweep jamming and dropping single bundles of chaff proved to be very effective. As a counterpoint, bad weather the next day (13 October) prevented use of ECM, and the strike force paid the price. Eastern Air Defense Force radar defenses and fighters "effectively nullified the strike forces." Coordination between radar stations and fighter direction was excellent, and the defenses were able to determine the aircraft tracks, the number of bombers in the formation, and the numbers of strike aircraft. Without the use of ECM, in fact, bomber cell formations provided radar directors with positive identification of the forces and made them more vulnerable to fighters.[36]

By the end of 1955 the B-47 had become SAC's primary combat bomber, and ECM was making a major contribution to its ability to penetrate Soviet defenses and reach its targets. At the same time, work was progressing on SAC's next

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[36]2nd AF History, Vol VII, July-December 1955, Exhibit 258, K432.01, in AFHRA.

"welterweight" jet bomber, the B-58 "Hustler." If the B-47 had been designed around speed and altitude as its key means of self-protection, the B-58 had these capabilities (mach 2.1 at 55,000 feet) in spades. The General Operational Requirement that served as the basis for the B-58 called for ECM systems that could operate as automatically as possible, an example of a persistent trend in SAC. In late 1952 Convair was selected as the contractor for a new bomber, designed to be small and fast. Like the B-47, the B-58 also had a three-man crew: pilot, "navbardier", and defensive systems operator. The third crewman was responsible for operating the tail gun and various ECM systems. General Partridge, the ARDC commander, felt that the missile, bombing, and ECM systems were particularly important. The details of the B-58 ECM suite are beyond the span of this study, but a few points are worth making. The ECM suite included the first production version of a "range-gate stealer", a jammer designed to induce ranging and deflection errors into tracking radars. Sylvania, the ECM contractor, was pushing to leap the ECM technology ahead, and it ran into difficulties as a result. One obvious problem with the "welterweights" was that their limited size and carrying capacity necessitated ECM gear be kept as small and as autonomous as possible. Both posed difficult tasks that in the event proved to be only partially soluble. The Air Force, operating on a philosophy that science and technology could be driven beyond the state of current technology, quickly and within affordable cost limitations, to meet operational requirements, would in the case of the B-58 eventually be disappointed. Fortunately, the Air Force experience with the "heavyweights", especially the B-52, would be different.[37]

New Bombers: the B-36 and the B-52 ... the Heavyweights

One crucial advantage held by the B-36, and later the B-52, was that its very size and load-carrying capacity gave it a great deal of growth room in which to incorporate new equipment or modifications, and to carry a combat crew that numbered (in the case of the RB-36D) more than 20 men, several of whom operated ECM equipment. The first operational versions of the B-36 entered service with SAC in mid-1948 and carried a crew of 15. At first the radio operator served as the additional duty ECM operator, as in the B-29. His standard operating procedures, in fact, did not even mention ECM, and the ground school training program for radio operators allocated more time to gunnery (20 hours) than it did to ECM refresher (18 hours). Yet the B-36's primary means of self defense would be its ECM capability, not its guns, and during much of 1951 B-36s from the 7th and 11th Bomb Wings flew test missions against Eglin AFB to evaluate the effectiveness of the jamming and chaff capability. These tests indicated that the B-36s could successfully penetrate existing radar defenses, and earlier tests against Royal Air Force night

[37]General Operational Requirement for Strategic Bombardment System, 8 December 1951, in Air Force Systems Command Historical Study on the B-58, K243.042-25; B-58 Development and Testing Program Summary, K239.046-19, both in AFHRA; R. Cargill Hall, "The B-58 Bomber: Requiem for a Welterweight", Air University Review, Vol 33 #1 (November-December 1981) p. 49; R. Cargill Hall, "To Acquire Strategic Bombers: the Case of the B-58 Hustler", Air University Review, Vol 31 #6 (September-October 1980) pp. 5-8, 17; Price, History of US Electronic Warfare, Vol II, pp. 244-245; I am indebted to Cargill Hall for the term "welterweights", which so aptly describes both the B-47 and B-58.

fighters equipped with airborne intercept radars were ineffective against B-36Bs equipped with their standard ECM suite. The B-36's best defense was a combination of poor weather, night, and ECM, not its guns.[38]

The SAC training programs cited earlier also applied to the B-36 crews, and the tough standards helped ensure that the crews would be as proficient as possible. Each wing, as required by SACR 50-25, established its own ECM school and ongoing training program. The records of several B-36 units provide details on these programs, which included up to 60 hours of instruction, divided between classroom lectures, hands-on work on equipment mockups, and in-flight practice. Some of the in-flight training could be accomplished in a trainer, but at least half of the requirement (570 hours per quarter per every 30 crews, or 19 hours per crew per quarter) had to be accomplished in the B-36. This was a taxing requirement, given the limited availability of aircraft, and highlighted the increasing attention focused on the ECM capability of the B-36 force.[39]

The B-36 and its reconnaissance version, the RB-36, were in the early 1950s better equipped with ECM systems than any other Air Force aircraft, yet all the

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[38]Meyers K. Jacobson, and Ray Wagner, B-36 in Action, (Carrollton, Texas, Squadron/Signal Publications, 1980) p. 18; "B-36 Radio Operator Procedures", and "4017th Training Squadron (B-36 Transition): Flight Training Ground School, Radio Operators Program, 416. 205B; 8th AF History, Vol II, July-December 1951, K520.01, all in AFHRA; Robert Hotz, "New B-36 to Give USAF Greater Range", Aviation Week, Vol 49 #16, (18 October 1948), pp. 12-14.

[39]22nd Bomb Wing Regulation 101-1, ECM Training Requirements, 25 January 1952; 11th Bomb Wing historical reports, January and February 1952, all in AFHRA.

jammers dated back to World War II. Only the APR-9 radar warning receiver and the A-6 and A-7 chaff dispensers were of modern design. The A-7, in fact, had been designed specifically for the B-36 and was capable of dispensing the "blockbuster" chaff bundle that was five times wider than the standard bundle and carried five times as much chaff. When ejected from the aircraft the chaff was intended to produce a large radar echo similar in size to the huge B-36. As new systems were developed and placed into operation the EW experts often had to work hard to keep the equipment close to the antennas and vice versa, for the further the antenna was from the actual jammer the more power was lost in the cabling, especially with the newer microwave jammers. Those radiating in the E-band, for example, lost half of the transmitted power for every 30 feet of cabling, and jammers in the I-band lost half of their power in only 10 feet! Thus one of the major advantages of the bigger airplanes such as the B-36, the size in which to place equipment, could also be a disadvantage because of the distances involved.[40]

Although SAC planned to phase out the B-36s by later in the decade, in 1954 they still were a key part of the SAC force, and that year SAC initiated a program that would over the course of the next eighteen months significantly upgrade the big bomber's overall combat capability. This series of modifications resulted in the so-called "Featherweight" B-36 and involved removing some equipment, modernizing others, adding new ECM gear, and raising the bomber's combat ceiling.

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[40]Price, History of US Electronic Warfare, Vol II, pp. 137-38.

Modernization of the ECM suite was a large part of this program, and its $30,000,000 pricetag included several significant equipment additions, such as a new radar warning receiver, two low frequency radar jammers, and the new APT-16 S-band jammer. The alterations also included the addition of another ECM operator position, so that there were individual crew positions for crew members operating low, intermediate, medium, and high frequency radar jammers. The old A-6 and A-7 manual chaff dispensers were replaced by the ALE-7 automatic dispenser. All in all, these modifications gave the B-36 an improved ECM capability, and certainly prolonged its operational usefulness; they could not, however, change the fact that the bomber itself was becoming inceasingly obsolescent in the face of Soviet interceptors that could fly higher and faster, and the development of surface to air missiles (SAMs). The B-36 had become a stopgap, and in the early 1950s SAC was preparing to add to its fleet the bomber that would become the mainstay of its force for more than three decades, the B-52.[41]

The story of the B-52, arguably the most successful (certainly the most long-lived) bomber ever built, began shortly after World War II, when the Air Force issued a series of operational requirements documents that set the stage for the

[41]WABC History, Vol III, January-June 1954, p. 302, and Vol II, July-December 1954, p. 245-46; 72nd Bomb Wing Historical Report, August 1954, Exhibit 16; all in AFHRA. Price, History of US Electronic Warfare, Vol II, Appendix J, has an extensive technical discussion of the B-36's ECM equipment in the early 1950s.

development of a new long range heavy bomber.[42] In late 1948 the Boeing design for a new long range bomber was accepted, and by early 1949 a mock-up had been approved. During a symposium on reconnaissance held at HQ SAC in November 1948, Captain Les Manbeck, the ECM expert at the headquarters, stated that "....the strategic bomber in the future will have to depend on altitude, speed, a tail gun turret...and electronic countermeasures for its defense." Although he did not specifically name the B-52 as the bomber in question, it was an accurate description, and in the fall of 1950 the Air Force Senior Officers' Board selected the B-52 as the successor to the B-36. During the first two months of 1951 the Air Force Chief of Staff, General Hoyt Vandenberg, and Secretary of the Air Force Thomas Finletter, approved this recommendation and issued a contract for the first thirteen production B-52A aircraft. One of the key aspects of this decision was the space and capacity the new bomber possessed in which to place ECM (and other) equipment. In November 1951 the XB-52 was rolled out of the factory for ground testing, followed in March 1952 by her sister, the YB-52. One month later, on 15 April 1952, the YB-52 lifted into the sky above the Boeing plant: the big bomber had made its successful maiden flight, and the evolution of SAC's bomber fleet had taken a major step forward.[43]

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[42]The basic story of the development of the B-52 is not essential to this story and has been related elsewhere; see Walter Boyne, Boeing B-52: A Documentary History (London; Jane's, 1981) for a fuller treatment.

[43]T. A. Marschak, "The Role of Project Histories in the Study of Research and Development", RAND Report #P2850, (Santa Monica, CA: RAND, 1964) pp. 92-93;

If one compares these first two test versions to the hundreds of later production models, from the earliest B-52A to the B-52H, probably the most striking visual difference is the switch from a tandem arrangement of the pilot and copilot to side-by-side seating, a change that General LeMay insisted on to improve crew coordination. A far more significant change, however, one that provided enormously increased combat capability, was buried within the airplane and not even visible from the outside: the addition of a sixth crew member, the electronic warfare officer (affectionately called the EWO) who was responsible for operating the bomber's suite of jammers, chaff dispensers, and ECM equipment. The B-52 was originally designed for a crew of five: pilot and copilot flew the airplane, the tail gunner protected its vulnerable "six o'clock" position, and a pair of navigators operated the bombing and navigational systems. Even before the first flight of the prototype YB-52, however, the EW experts at SAC and the Air Staff urged a reexamination of the bomber's ECM capability. Major Robert Perry, head of the EW branch at SAC, returned from a conference held at Boeing in September 1950 to discuss B/RB-52 design trends and suggested to General LeMay that the airplane needed a dedicated ECM operator. General LeMay, obviously influenced by his knowledge of the contribution EW had made to bomber survivability in 1945, agreed.[44]

Boyne, B-52, p. 34; Presentation by Captain Les Manbeck to the SAC Reconnaissance Symposium, 22 November 1948, in Sac History, 1948, 416.01; SAC Requirements for Long Range Strategic Striking Force, 1950-52, K416.04-4, in AFHRA.

[44]Price, History of US Electronic Warfare, Vol II, pp. 73-74; "B/RB-52 Airplane Design Trend Conference", 7 September 1950, in RG 341/D5, DCS/Development,

General LeMay's decision to modify the B-52 to add an ECM operator was extremely important, yet the the documentary record of the decision is virtually nonexistent. One major Air Force historical study of the development of the B-52, for example, discusses the change from tandem to side-by-side flight crew seating in minute detail but fails to even mention the addition of a sixth crew member![45] In late October 1950 General Power notified the Air Force Director of Requirements that an ECM operator position should be added to the B-52. Although SAC still wanted an automated ECM system that could jam GCI and airborne intercept radars as well as ground and air launched missiles, the ECM operator was necessary to provide the new bomber with the maximum self-protection capability. A few weeks later the Air Staff notified SAC that Boeing had been requested to make the desired change. The Requirements Directorate had just completed a survey on ECM equipment applicable to the new jet bombers, the B-45, B-47, and B-52, and "strongly recommended" providing the B-52 with a full-time ECM operator. The survey noted that without a ECM operator in the aircraft (currently possible only in

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Director of Requirements, Box 170, in NARS.

[45]Brown, Flying Blind contains a detailed discussion of the B-52 development process, including the issue of the tandem cockpit and the tail gun, but ignores the electronic warfare officer and ECM. Marcelle S. Knaack's volume on Post-World War II Bombers: 1945-1973 in the Office of Air Force History's series Encyclopedia of U. S. Air Force Aircraft and Missile Systems (Washington, DC: OAFH, 1988) has a great deal of detailed technical and developmental information on each B-52 model, yet it, too, does not mention the addition of the 6th crewmember. None of the published histories of the B-52, in fact, touch on the story of the addition of the ECM operator position to the aircraft.

the B-29, B-50 and B-36 bombers) only preset jammers could be used, which had very limited effectiveness. All jammers currently in use required a qualified operator to be fully effective, and improved versions of the equipment would only intensify the need. The relative alacrity with which SAC recommended, and the Air Staff endorsed, this modification may mask the amount of work it required of Boeing. Adding a crew position required an extensive redesign of major portions of the bomber and certainly helped delay its completion. The YB-52 first flew in April 1952, but 28 months would pass until a production B-52A with the EWO position installed would make its first flight in mid-summer 1954.[46]

Even though the Air Force was only five years removed from the massed thousand bomber raids of World War II, SAC's tactical doctrine of small formations of only a few aircraft meant that a combination of chaff and jamming would be its most effective system for bomber self defense. The survey completed by the Requirements Directorate acknowledged that aircraft that did not carry an ECM operator had little chance of successfully jamming enemy airborne or GCI radars, because most of the radar frequency bands were open. By 1952 the situation would improve slightly, because the addition of the APT-16 jammer would significantly increase both the jamming power and frequency coverage available against the

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[46]Letter, SAC Deputy Commander to Air Force Director of Requirements, 25 October 1950, subj: B-52 Defensive Capability, and Air Force Director of Requirements reply to SAC Deputy Commander, 27 November 1950; "Survey Report on ECM Equipment Applicable to B-45, B-47, and B-52 for both Defensive and Electronic Reconnaissance Purposes", 30 October 1950, both in RG 341/D5, DCS/Development, Director of Requirements, Box 170, NARS.

S-band in which the Soviet Token radar operated. Even here, however, the full capabilities of the new jammer would be lost without an ECM operator for the equipment. This held true for equipment anticipated during each of the next two years as well. Without a crew member assigned to operate the new jammers, little was to be gained from installing preset jammers in the new B-47 and B-52 jet bombers. The B-47, as already discussed, would be equipped with the "Blue Cradle" modification that installed a manned jamming pod in the bomb bay. This limited the aircraft to an escort role, however, and negated its potential as a bomber. The B-52, because of SAC's decision to redesign the bomber to include a full-time ECM operator, would be able right from the start to carry and employ a full suite of chaff, jammers, and ECM gear as well as bombs. It was an extremely beneficial decision with long-term consequences. Forty-one years later B-52s would be in combat over Iraq during the Gulf War, and although the tail gun position had become an anacronism the EWOs were kept busy jamming Iraqi radars and decoying Iraqi SAMs. Indeed, one key reason for the B-52's combat effectiveness through the years has been its EW capability, for the big bombers' primary moments of combat (over Hanoi in December 1972 and over Iraq in January-February 1991) have both featured their ability to fight and survive against the enemy's electronic threats.[47]

By 1955 the Strategic Air Command had developed a solid capability to use a wide range of EW systems in combat, and its potential to successfully carry out its

[47]Ibid.

primary strike mission rested in large measure on these systems and the men who operated them. This does not, of course, mean that there weren't problems or snags. The relatively rapid increase in the size and scope of the Air Force EW program was itself a source of difficulty, because as new equipment such as jammers and chaff dispensers were developed and put into production, aircraft had to be modified to carry them. The B-52 test program was frequently interrupted by ECM changes, and the proficiency of ECM operators (primarily the enlisted operators on the B-50s and B-36s) was often a problem. By 1955, though, significant progress was being made on a large number of new ECM devices beyond those already developed and deployed in the previous few years. Especially encouraging were the promising results of the tests carried out on the B-52's first complete ECM suite.[48]

From the dismal days of the late 1940s when General LeMay took command, SAC had come a long way and was, indeed, the model for the rest of the Air Force. Clearly, SAC's senior leadership, from General LeMay on down, were aware of the need for and valued the combat capability offered by new electronic warfare systems and personnel. This awareness, which had its roots in the experiences of World War II and later Korea, was probably the key reason for the advances made in SAC's EW capability. Sadly, the same could not be said for the Air Force's other major combat

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[48]Memo, Director of Communications-Electronics Division, HQ SAC to Director of Operations, HQ SAC, 18 May 1951, subj: SAC ECM Program for Bombardment Aircraft, in SAC ECM Study; Memo, Chief Strategic Systems Division, HQ USAF, to Deputy Commander SAC, 14 July 1954, subj: B-52 Flight Test Program, in ARDC History, Vol III, July-December 1954, K243.01; WADC History, Vol II, p. 335, January-June 1955, K243.011; all in AFHRA.

organization, the Tactical Air Command (TAC). If SAC was the model for what could be done with EW when its capabilities were appreciated, TAC was the model for what could happen when these capabilities were ignored.

CHAPTER NINE

"HAVE DOCTRINE, NEED CAPABILITY": TAC AND EW

When the Tactical Air Command was established in 1950 it may have lacked aircraft, but it did have an electronic warfare policy and a staff section, albeit small, that established equipment requirements and wrote EW doctrine. During the early 1950s TAC had almost no EW capability, and had little success turning equipment requirements into actual hardware. The Korean War provided an opportunity to field test a possible solution to what may have been TAC's greatest EW need, an ability to locate, home on and destroy enemy radars. This "radar buster" was deployed and tested but found wanting, and TAC eventually ended the decade without a suitable capability to attack enemy radar defenses. TAC did publish a very thorough EW doctrine, but did not develop the hardware and systems to put it into practice. In part this resulted from technical difficulties, but in equal measure resulted from attitudinal factors and lack of support from the senior leadership.

The TAC EW Program

In the early 1950s the placement of EW within the HQ TAC staff was comparable to its position in SAC, an ECM section within Communications-Electronics, although at TAC Communications-Electronics was a full-fledged DCS itself and not under the DCS for Operations.[1] Even though TAC had virtually no

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[1]Eventually, in 1957, HQ TAC was reorganized and the Communications-Electronics area "demoted" to a Directorate under the DSC/Operations, which mirrored the SAC pattern. This was accompanied, not surprisingly, by a 30% cut in authorized personnel. Although this falls outside the bounds of this study, this reorganization cannot have been helpful to the position of EW within TAC, and may well have contributed to the general decline in EW awareness that pervaded TAC

EW capability at this point, the small EW staff was involved in planning for the future and was a full participant in various EW conferences and bodies, such as the chaff consultation group that met at Eglin AFB. The TAC history for 1952 contains repeated references to EW and ECM, including a lengthy section describing policy, tactics, systems, capabilities, and employment. The details are essentially identical to other descriptions of EW capabilities and employment described elsewhere in this study and need not be repeated here: the important point is that TAC was actually considering them in 1952. Indeed, they were amplified and formalized in the "Doctrine Governing Mission and Command Functions of ECM in Tactical Air Operations" that TAC published in November 1952.[2]

Earlier in 1952 TAC formed an ECM Board to oversee EW activities in the command. Comprised of representatives from Communications-Electronics, Operations, Maintenance & Supply, Intelligence, and Operations Analysis, the Board's mission was to monitor all ECM activities within the command, determine types of installations, tactics, and techniques to be employed, and expedite action on all TAC ECM projects. TAC noted the success that the SAC EW Board was having in guiding EW activity within that command, and obviously wished to emulate its

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until combat operations (and losses) in Vietnam sent the strongest possible "wake-up call".

[2]TAC History, Vol III, Supporting Document 12, January-June 1952, K417.01; TAC History, Vol V, July-December 1952, K417.01, both in AFHRA; Telephone Interview with Walter Stachura (Colonel, USAF, Ret.), 1 March 1990. See Chapter Seven for a fuller discussion of the TAC doctrine and its follow-on, published in 1955. Colonel Stachura was the author of this 1952 EW doctrine.

actions. One serious shortcoming that hampered such success, however, was the lack of ECM expertise within the command. In mid-1952 TAC was authorized 28 ECM officers but had only 13 assigned, and the future prognosis was even worse: the predicted impact of overseas deployments and transfers was that by the end of the year only five qualified ECM officers would remain in the entire command. This occurred just as TAC's requirements were increasing, given projected aircraft modifications and increased training.[3]

One of TAC's pressing needs was to determine exactly what kinds of EW capabilities were most necessary for its forces. Early concerns centered on the vulnerability and survivability of low-flying aircraft when conducting ground attack-type missions such as close air support or interdiction. Low altitude attacks were one tactic that could be used to evade radar detection, but it was understood that improvements in radar would eventually reduce the advantage offered by this procedure. By 1952 TAC had established ECM capability requirements for three different categories of aircraft. Night intruders needed the ability to screen themselves with chaff reflectors, and to possess a limited electronic jamming capability; tactical bomber, troop carrier, night and electronic reconnaissance needed both jamming and chaff capability; and daytime fighter, fighter-bomber, and reconnaissance aircraft needed only a chaff capability. In addition, TAC needed the

[3]TAC History, Vol II, pp 44-45, and Vol V, pp. 61-65, January-June 1952; HQ TAC Record and Routing Sheet, subj: ECM Board in TAC, 9 May 1952, in TAC History, Vol V, January-June 1952, K417.01; all in AFHRA.

ability to detect, home on, and destroy installations and sources of electronic radiation. These closely tracked with the operational requirements stated in TAC's EW doctrine, and indicates a relatively close relationship between doctrine and requirements. There was a growing awareness that radar posed a threat to TAC's ability to operate unhampered over the batlefield, and that mobile radars posed a unique threat that was of more concern to TAC than SAC. The basic intent was to provide most TAC aircraft with a defensive ECM capability, particularly a radar warning receiver (RWR), to alert fliers that they were under radar observation, and a chaff dispensing system, to protect them from enemy radar-guided missiles and radar controlled flak.[4]

TAC's equipment requirements for individual aircraft focused on these relatively modest radar warning and chaff dispensing capabilities, and some success was obtained with the eventual production of the APS-54 RWR and the ALE-2 chaff dispenser (the same equipment carried aboard the B-47 bomber), although most of the work on these systems took place outside the bounds of this study. In TAC these were carried primarily by fighter-type aircraft, although not every TAC aircraft was equipped with even these modest systems. The F-101, for example, did not have any radar warning capability; in fairness, however, since it was designed as an interceptor it did not need this capability as much as an aircraft that would penetrate enemy

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[4]California Institute of Technology, "Project Vista Interim Report", 1951, K146.003-137; ARDC Quarterly Review, p. 73, September 1951, K243.1251; TAC History, Vol I, pp. 37-38, and Vol II, p. 87, July-November 1950, K417.01; all in AFHRA; Stachura interview.

airspace and operate in the face of significant enemy ground-based air defenses. Another future TAC mainstay, the F-105, had its proposed ECM capability eliminated by the Air Force Configuration Board in a cost and weight saving measure. The failure to provide the F-105 with this modest EW capability is a telling indictment of TAC's attitude towards EW and its ability to learn the lessons of the Korean War, for the F-105's primary mission was not as a fighter but rather as a bomber, including delivery of tactical nuclear weapons. These missions would have taken the F-105 into the heart of the enemy's ground based air defenses that relied heavily on radar, yet this fact, learned at great cost in Korea, was essentially ignored. The APS-92 radar warning receiver, ALE-2 chaff dispenser, and the ALQ-31 jammer would have provided at least a basic ECM suite; ten years later some F-105 pilots would wish that the Air Force had spent the $105,000 it saved per aircraft and retained this capability.[5]

Most of TAC's EW work during this period centered on the development of the B-66. Since the prevailing view in TAC was that fighters were too small to carry ECM gear, the B-66 was intended to perform the overall roles of electronic

[5]TAC History, p. 326, January-June 1957 (of which pp. 317-332 are a survey of the TAC EW program since 1950), in AFHRA; David Anderton, Republic F-105 Thunderchief, (London: Osprey Publishers, 1983), p. 74. The F-105 was tagged with a myriad of unofficial nicknames during the war..."lead sled", "ultra hog", and "Thud" were just three of the most common ones, all reflecting its poor air-to-air maneuvering (ie. fighter plane) characteristics; it wasn't a fighter...it was a fast single-seat bomber. Colonel Jack Broughton, in his bitter memoir of the air war over North Vietnam Thud Ridge (Philadelphia, PA: Lippincott, 1969), decries the Air Force's "inability to pinpoint gun or SAM sites and radar control stations."

intelligence platform and ECM jammer and escort. As early as 1952 the Air Force directed placing active ECM gear (the ubiquitous ALE-2 and APS-54) on the B-66, and confirmed this requirement the following year. As with so many other ECM R&D efforts during this period, however, the reality of technological limitations outweighed the operational requirements established for the airplane. Unattended and autonomous ECM devices, such as SAC wanted for the B-47 and B-58, were still in what would become a long and rocky developmental process, aggravated by space problems in the already-jammed B-66. To top it all off, procurement lead times were long and uncertain. The RB-66 was to be the torchbearer of TAC's ECM program, it was hoped, but in the mid-1950s the program was in trouble. The Air Force and Douglas Aircraft set up a new, nine-phase interim ECM program in early 1955, but by the end of the year little had been accomplished, and it was clear that additional changes would be necessary to make the B-66 effective. Despite being "loaded" with potential, not until the late 1950s, when the "Brown Cradle" ECM pallet for the B-66's bomb bay was developed, would the B-66 begin to demonstrate some operationally-useful ECM capability.[6]

"Radar Buster"-- the first "Wild Weasel"

Even during World War II airmen realized the advantages that would result from destroying enemy radar systems. In mid-1944 the Mediterranean Allied Air

[6]TAC History, pp. 327-328, January-June 1957; Air Materiel Command Historical Study #324, "History of the B/RB-66 Weapon System (1952-59)", pp. viii, 26-29, K201-99; both in AFHRA.

Forces determined that the most vulnerable part of German radar systems was the control cabin that housed the key electronic gear and the system operators, and recommended strafing and cannon-fire as the the most damaging weapon for attacks. In the Southwest Pacific, both 5th AF and 13th AF equipped a B-25 with radar search receivers to enable them to seek, bomb and strafe Japanese radars in one fell swoop. The Army Air Force magazine Radar printed a unique series of photographs in June 1945, depicting several attacks by B-25 "radar busters" on Japanese radars in the Philippines, stating that more than 50 such radars had been silenced. What was surprising is that there is no evidence that this promising capability was further pressed or developed after the war, another example of a promising "lesson learned" that was ignored, forgotten, or never codified in the postwar rush to demobilize.[7] Not until the outbreak of the Korean War did the need for the radar buster surface again, and to adequately tell this story we must return to the Korean War.

At first the tactical air forces in Korea did not worry about enemy radar; aside from the general absence of it, the fighters and light bombers had enough to do dealing with light flak. By early 1951, however, 5th AF was trying to reduce the loss rate for B-26s (the World War II A-26 "Invader") and concluded that perhaps

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[7]Mediterranean Allied Air Forces, "Enemy Ground Radar", August 1944, 622.654-2; "The Search for Jap Radar", Radar, pp. 9, 37, 30 June 1945, 143.501B, both in AFHRA. During the Vietnam War the Air Force initiated a crash program to develop a radar hunter-killer capability. Using F-100s at first, the program eventually settled on the F-105, modified to carry a second crewmember who operated the radar search and weaponeering gear. These modified F-105s came to be known as "Wild Weasels"; the F-4G, which inherited the mission also inherited the name, and the Air Force refers to the radar hunter-killer effort by this nickname.

enemy radar was being used to vector enemy fighters into attack positions. As a result, the Directorate of Electronics initiated a project to install radar direction finding gear in a B-26 that could seek out and destroy enemy radar sites. The 452nd Bomb Group (BG) modified one of its B-26s in March 1951 by installing a signal intercept receiver and direction finding antenna, and the radar buster effort was reborn.[8] Throughout 1951, 5th AF constantly attempted to identify and neutralize enemy radars and VHF jammers. In early July the 452nd Bomb Group's ELINT-configured B-26, the only one in the Far East Air Forces (FEAF), was transferred to the direct control of 5th AF, and that month it flew eight missions along Korea's west coast, which included some of the main supply routes for enemy forces. The next month FEAF authorized the modification of two more B-26s for ELINT work, but not until November did 5th AF notify FEAF that the aircraft had been sent to the depot and were ready to begin modification. This would not be the last delay in this project.[9]

5th AF hoped to have the two special B-26s in operation by mid-February 1952, which would then give them a total of three B-26s configured to locate enemy early warning, ground controlled intercept (GCI), and flak control radars, in addition to

[8]The 452nd BG was also tapped to start a "jammer buster" effort, designed to overcome enemy jamming of friendly VHF radio communications, which was successfully tested in April 1951. This is an example of electronic counter-countermeasures (ECCM) and thus outside the purview of this study.

[9]5th Air Force History, Vol II, pp. 74-76, January-June 1951; Vol I, pp 199-201, July-December 1951; both in AFHRA.

locating enemy VHF radio jammers. These two aircraft would then rejoin the original B-26, which had been reassigned to the 67th Tactical Reconnaissance Wing. Their mission was limited, however, solely to locating enemy radars, not attacking them. Only VHF jamming sites were to be attacked. 5th AF objected to this policy, which stemmed from FEAF guidance on ECM employment, claiming that enemy radars were more vulnerable and more valuable than flak guns that they were allowed to attack. 5th AF wanted enemy radars placed in the same classification as supply dumps, airfields, and other such targets they were routinely attacking. FEAF concurred with this proposal, but only partially; flak control radars were available for attack whenever encountered, but early warning and GCI radars were still off limits from direct attack.[10]

5th AF, which had on hand or soon expected to have a small quantity of ARQ-8 jammers, quickly proposed a tactical doctrine for light bomber ECM operations, which called for the ECM-configured B-26s to escort attack aircraft into a target area and remain there until the attack was completed. Shortly after FEAF granted its approval, 5th AF noted that enemy opposition had significantly increased. Since early in 1951 the enemy's interception of night intruder operations had more than doubled, and fighter-bombers operating in the Sinanju area (the heart of "MIG

[10]5th Air Force History, Vol I, pp. 199-205, July-December 1951, and supporting correspondence in Vol II, pp. 113-125, K730.01, all in AFHRA. The documentary record does not indicate the reason for this prohibition, but in 1952 the JCS urged Far East Command to loosen its restrictions on the use of ECM and chaff. This prohibition may have resulted from a desire to continue ELINT-gathering operations against the enemy radars, and thus did not want them destroyed.

Alley") had been intercepted almost daily. Of the two means of reducing enemy radar effectiveness, destruction was far more cost effective than jamming. Current 5th AF ECM capability was limited to five B-26s with jammers in each of the two light bomber squadrons, and the one B-26 equipped with obsolete direction finding equipment. In late October 5th AF again called to FEAF's attention the desirability of attacking any and all enemy radar sites, and outlined the technical difficulties encountered in locating those radar sites. The direction finders carried by the B-26s (APA-17s or APA-24s) were antiquated and could not provide sufficient detail to pinpoint the location of enemy radars, since the area where the radar might be located was several miles across. Photographic reconnaissance aircraft had to overfly the area, and even then often failed to detect where the site was located. FEAF, while acknowledging the desirability of negating enemy radars, essentially upheld the restrictive policy of not bombing any other radar target than flak control without first contacting FEAF for permission.[11]

Regardless of what types of radars 5th AF was authorized to attack, however, the simple fact remained that the "long pole in the tent", the B-26 busters, were proving to be very difficult to obtain. Although February 1952 was the target date for completing the necessary modifications, a variety of factors combined to push the estimated completion date further into the future, even as the requirement was raised

[11]5th Air Force History, Vol I, pp. 199-205, July-December 1951, and supporting correspondence in Vol II, pp. 113-125, K730.01, all in AFHRA; Price, History of EW, Vol II, p. 104.

from two to five bombers. The one B-26 buster that was operating (aircraft serial #44-34571) could conduct only a limited number of sorties, and even these were nothing more than operational tests of a developing capability. The fighter units were beginning to report increased enemy interceptions, and they requested assistance in countering the enemy's new radar-assisted methods, even as the estimated completion date was slipped six months, into August 1952. Equipment shortages played a part in this delay, as did fluctuations in the priority of the project, which for a while threatened to keep it in permanent limbo. Equally important were factors such as a general lack of knowledge about enemy radars and what 5th AF termed "a lack of a sense of urgency" on the part of some at FEAF Materiel Command concerned with the buster project. The 5th AF Director of Intelligence was not one of these, however, and in July he advised the Director of Operations that the ECM aircraft were as important as the F-86 or any other fighter: "The highest priority possible [ought to] be given to Project 528 to expedite the delivery of these aircraft to Fifth Air Force."[12]

The constant nagging by 5th AF bore fruit, as the first of the ECM-configured B-26s was delivered to the 67th wing in October 1952; two more followed in November, and another in December. This did not mean, of course, that they were

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[12]5th AF History, Vol I, pp. 151-156, and letter, 5th AF to Commander 67th Tactical Reconnaissance Wing, subj: Use of B-26B #44-34571 ("Buster") to Destroy Enemy Radars, 22 April 1952, in Vol II, pp. 143-144, K730.01; Memo, 5th AF Communications-Electronics Directorate, "Electronic Countermeasures", 1 January 1952, K730.901A; 5th AF History, Vol I, pp. 156-158, July-December 1952, K730.01; all in AFHRA.

ready to begin combat operations immediately, for there were equipment tests and calibrations and flight tests required. By the end of the year, however, they had conducted nearly fifty missions. Each aircraft carried a crew of three men: pilot, navigator, and ECM operator. The gun turrets and central fire control system had been removed to save weight and provide space for the ECM equipment and operator, who occupied a position in the modified bomb bay. 5th AF was anxious to begin operations, and in November 1952 it developed what amounted to a tactical doctrine for the employment of the new aircraft. Their objectives were to locate and destroy the enemy GCI capability that was being blamed for their fighter attacks on friendly bombers, and to reduce the effectiveness of enemy radar controlled searchlights and guns. Earlier that summer 5th AF had devised a plan which would divide the operational area into blocks that would be searched until positive results were obtained and radar sites destroyed. The 67th wing received assistance in this effort from an unexpected source: the US Marine Corps, whose First Marine Composite Squadron (VMC-1) was equipped with AD-2Qs capable of both direction finding and attacking enemy radars. As with the Air Force, however, the Marines had the same difficulty pinpointing the radars' precise position, with accuracies measured in miles. Before the enemy's radars could be attacked, therefore, photo interpretation of the suspected site would be required. FEAF's answer to the overall problem was to propose the development of a special program to develop an ECM system using an infrared seeker to locate radar emitters. This could be done within twelve to fifteen months, and it should be deployed within a dedicated ECM squadron, which would itself be assigned to the 67th TRWg. When FEAF requested 5th AF comments, however, that organization replied that the development of a hunter-killer ECM aircraft using infrared would be "tactically unsound", because the device FEAF hoped to use (the AN/AAS-1 heat seeker) had already been tested, with poor results. This was borne out by tests the 3rd Bomb Wing conducted in March 1953, in which the seeker could not distinguish between the radar emitter and other nearby heat sources. Additionally, 5th AF considered the few B-26s configured to search for radars to be far too valuable to risk in the same way as other bombers. 5th AF did concur with a suggestion to activate a dedicated ECM squadron that would perform ELINT, jamming, and evaluation, while the killer portion of the hunter-killer team would be another combat aircraft.[13]

By the start of the new year the radar buster project had certainly achieved mixed results. On the one hand, a few aircraft had been modified and were being operationally tested. On the other hand, the testing program was proving to be lengthy; worse, the tactical results obtained on the approximately 100 combat missions eventually flown were generally unsatisfactory, primarily because of the lack of precision and accuracy of the radar intercepts the planes were able to make. Both the RB-26s and the Marine aircraft could only plot a radar site to within about

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[13]5th AF History, Vol I, pp. 156-161, July-December 1952; Vol II, Appendix 129, Operational Suitability Test of the B-26 Electronic Reconnaissance Airplane, undated, and Appendix 130, letter, 5th AF to Commander 3rd Bomb Wing (L), subj: Use of Active Electronic Countermeasures by 5th Air Force, 28 November 1952; 67th Tactical Reconnaissance Wing History, May, July-December 1952; 5th AF Operations Program, ECM Report, April 1953, K730.211A-5; all in AFHRA.

three miles of its exact location, certainly not close enough to schedule a killer mission. Shortly after the war ended the 67th wing completed project "Bird Dog", which was yet another test of the RB-26's radar direction finding and homing capability. Special equipment to test homing on L-Band (390-1550 MHz) and S-band (1550-5200 MHz) radars were installed. The test proved once again that the 5th AF buster could not do the job; the radar buster project in 5th AF was essentially a failure.[14]

At the same time 5th AF and FEAF were attempting to implement the "radar buster" concept, TAC was doing the same thing back in the U.S. In November 1952, 9th AF declared its need for an aircraft capable of detecting, locating, and destroying hostile radars and electronic systems, and suggested the use of either a heat seeker or radar beam rider to meet the requirement. If one aircraft was unable to perform the full mission, 9th AF said, a hunter-killer combination should be developed. This idea was not unique to 9th AF, of course; all through 1952 the Air Staff EW section at the Pentagon had discussed attempting to modify B-26s to serve as jammers and radar hunter-killers. TAC personnel had visited Korea in 1952 and observed the B-26 project there, but the feedback from those visits was informal, with no indication that they helped to shape the buster project underway in the U.S. TAC had already issued Qualitative Operational Requirements documents for an infra

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[14]67th Tactical Reconnaissance Wing History, January-June and July-December 1953; 5th AF History, Vol I, January-June 1953, K730.01; 5th AF Operations Program, ECM Report, April-May 1953, K730.211A-5; all in AFHRA

red search and detection device, an infra red target seeker, and an airborne detection and homing system, and eventually all were validated by HQ USAF and entered into the R&D process. Yet all eventually came to naught, and by the late 1950s the Air Force still did not have a workable radar hunter-killer capability. The problem of detecting and jamming a radar signal was far easier than detecting it and pinpointing the point of origin sufficiently closely to enable firepower to be brought to bear against it. The Air Force was unable to mold the team of science, industry, and the combat operators themselves that was put together in the 1960s during the crisis over radar-guided SAMs used by the North Vietnamese. There were several factors involved in the failure of the radar buster; partly it was a lack of sense of urgency, and partly it was the inability to solve the technological problems inherent in this effort, but the fundamental cause was that it simply was not one of TAC's high priority problems. It reflected TAC's failure to think through the future threat from ground based air defenses, which is in part a doctrinal failure. The end result was that the Air Force was little closer to a radar buster in 1955 than it had been in 1950. The bill for this shortcoming would come due in the unfriendly skies of North Vietnam.[15]

Training and Exercises

During 1953 several elements of TAC were experimenting with ECM, either to

[15]TAC History, vol V, pp. 31-36, July-December 1952, K417.01, in AFHRA; Stachura Interview; 5th AF History, Vol I, July-December 1953, K730.01, in AFHRA

aid fighters and bombers directly, or to assist radar detachments to help recognize and counter the effects of potential enemy use of jamming and chaff. The B-26 proved to be a popular airframe for this mission in Europe and the U.S., as well as in Korea. In Europe, 12th AF "borrowed" two ECM-equipped B-26s from TAC to begin training ground radar personnel on how to deal with enemy EW. TAC had received its first ECM-configured B-26s in 1953, and assigned them to the 9th Tactical Reconnaissance Squadron, part of the 363rd Tactical Reconnaissance Wing at Shaw AFB, South Carolina.[16] They carried radar receivers and direction finders, as well as some old jammers and chaff dispensers. Realizing that "borrowing" aircraft was at best a temporary solution, in early 1954 the United States Air Forces in Europe (USAFE) activated two units whose missions focused on EW: the 7311th ECM Training Flight, equipped with three B-26s, whose mission included training ground radar stations; and the 7366th ECM-Radar Evaluation Squadron, equipped with B-29s. USAFE, aware of the increasing Soviet deployment of modern radars throughout Eastern Europe, was considering the development of jammer escorts that could assist strike aircraft in penetrating the Soviet defenses.[17]

Elements of TAC halfway around the world from Europe were engaged in similar efforts to improve their EW capability. In Alaska, an ECM Training Flight

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[16]The 363rd now flies F-16s out of Shaw, and played a significant role in the Gulf War.

[17]USAFE History, Vol V, pp. 8, 14-15, July-December 1952, Vol VII, pp. 8-12, July-December 1953, and Vol V, pp. 7-10, January-June 1954, K570.01, all in AFHRA; Price, History of US EW, Vol II, p. 144.

attempted to provide a minimum ECM training capability, but equipment shortages limited the operation to just two old B-29s, only one of which could conduct actual jamming. The other B-29 had no jamming gear and was thus limited to manually dropping chaff through the camera hatch! Closer to Korea, the Japan Air Defense Force (JADF) spent part of its time observing Soviet use of jamming and chaff and reporting on what was seen. In early 1954, for example, the Soviets were observed dropping chaff over Sakhalin Island, which JADF assessed as a possible training exercise for Soviet searchlight control radars. The JADF began using an ECM-equipped B-26 in mid 1954 to provide jamming training to ground radars, and the missions were so successful that JADF requested two more from FEAF, one for each of the two fighter wings in the JADF.[18] A key point common to the situation in USAFE, Alaska, Japan, and the U.S., however, is that the primary mission for these aircraft was usually to provide EW training for ground radars by exposing them to jamming and chaff. Their focus, in other words, was inwards, to improve the Air Force's use of ECCM and defensive efforts, not outwards, to use ECM to assist the accomplishment of bomber and offensive strike missions.[19]

TAC's efforts at exercising its nascent EW capability during the early 1950s only

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[18]These may have been the "busters" modified during the Korean War, but the records are not precise enough to determine this.

[19]Letter, Commander of 5039th Air Transport Squadron to Commander 5039th Air Transport Group, subj: Capabilities of the ECM Training Flight, 16 November 1953, in History of 5039th Air Transport Wing, July-December 1953; History of the Japan Air Defense Force, Vol I, pp. 110-124, July-August 1954, K719.01; all in AFHRA..

served to point out how limited that capability was. Two examples will serve to illustrate this. In early 1952 TAC assigned two B-25J bombers to conduct ECM operations in conjunction with exercise Long Horn. Both B-25s were relatively well equipped, with each bomber carrying two APT-5 and one APT-16 jammer. Each carried the old and unreliable A-1 chaff dispenser, and one of the ECM objectives was to test the use of chaff at low (1,000-4,000 feet) and medium (4,000-10,000 feet) altitudes. Another goal was to evaluate the APT-16 jammer, which was in short supply throughout the Air Force. The ECM-configured aircraft had good success, both with jamming and with chaff. The chaff drops, especially, caused great confusion among ground radar operators, as the chaff clouds appeared as small fighter formations for as long as fifteen minutes. One of the most significant benefits was to give TAC personnel experience in planning and employing ECM in support of tactical air operations. Umpire reports and the observations of the ECM officers indicated that most participants took ECM too lightly. They were unaware that the primary goal of the ECM operator was merely to cause a few minutes' indecision or uncertainty on the part of the ground radar staff. With the speed of modern aircraft that was enough to enable them to avoid the defenses[20]

Exercise Long Horn was a relatively small operation, and tactical planning for ECM employment in TAC was still in its infancy, especially as contrasted with SAC.

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[20]Memorandum, Summary Report of ECM Operations, Exercise Long Horn, 9 April 1952, in History of 5th Radar Calibration Flight, January-May 1952, in AFHRA.

TAC personnel learned useful lessons about planning ECM operations, but the lack of capability hampered the ability to put these lessons into practice. Three years later, in November-December 1955, TAC mounted a much larger exercise, Operation Sagebrush, to practice and evaluate joint air-ground operations. It did not involve forces from either SAC or ADC, so that only TAC and Army forces were involved. The lack of progress TAC had made in developing an offensive ECM capability was highlighted by the meager forces it could contribute, only 3 B-26s and 2 B-25s for active ECM and 5 RB-26s for ELINT gathering. These few aircraft operated in conjunction with Army ground-based EW systems, equally divided between the two sides in the exercise. During one phase of the exercise problems developed when the EW effort was placed under the control of the Army signal officer, whose concept for the use of ECM was so restrictive as to make it useless. Part of the difficulty here was the lack of rank and experience on the part of the Army personnel. The differences between Army and Air Force EW employment doctrine was a potential problem area that perhaps no one had forseen, because EW operations had generally not been undertaken as part of a joint land-air operation. Such operations had taken place occasionally during World War II, specifically during the German Ardennes Offensive of 1944-45, but evidently the "lessons learned" from this usage were never codified. Later in the exercise the Air Force was given freer rein to employ EW in accordance with Air Force doctrine. Perhaps the ground radar personnel were better trained or equipped, and the relative paucity of the airborne ECM capability certainly was a factor, but the airborne jammers were generally unsuccessful in penetrating the radar coverage. Nothing better illustrates the gulf that existed between SAC's and TAC's EW capability in 1955 than the ECM forces that could be devoted to exercises of this nature, for while TAC could only bring ten outmoded B-25s and B-26s to Sage Brush, SAC was routinely putting several dozen bombers and ECM jammer escorts from the 376th Bomb Wing up for exercises and evaluations.[21]

Summary

Despite the technical and equipment limitations faced by the TAC EW program in the early to mid 1950s, the greatest impediment to developing a real ECM combat capability may have been between the ears of TAC personnel, an attitudinal handicap that no amount of technology could overcome. Part of the problem may have been bureaucratic and organizational. Since within TAC EW was not considered to be a weapon system by itself, nor a part of a recognized weapon system, it had no significant "patron" in the budget and weapon acquisition procedure at TAC. In a process that was dominated by different "shops" that pushed their own interests -- fighter-bombers, reconnaissance, and of course "pure" fighters -- ECM was perhaps inevitably left out in the cold, alone, unappreciated, and unsupported. Not until later in the 1950s were ECM officers assigned to any office in the headquarters other than Communications-Electronics, when several were assigned to DCS/Iintelligence. The contrasts with SAC, which as previously discussed had closely integrated EW in its

[21]"Communications-Electronics in Exercise SAGE BRUSH", K417.7176-16; Memo for Chief Special Staff Group, "Brief on CE Program Area", 5 April 1956, K168.1501-28; both in AFHRA.

operational planning process, are striking.[22]

There were other, more emotional factors affecting the TAC EW program. One account of TAC during this period stated, in reference to the early effort to provide a B-26 escort jamming capability, that "it aroused little interest within the command and little was expected of it." Often the jamming capability TAC did possess was used primarily for training ground radar personnel in tactics to circumvent enemy jamming, which should have been a clear lesson on what friendly ECM could therefore do to the enemy! The indifferent level of interest matched the low level of capability. "The command was populated mainly by fighter and fighter-bomber pilots who relied on surprise, speed, maneuverability and skillful low flying to survive."[23] One of the EW officers at the Air Staff during the period, Captain Jerry Sensabaugh, discussed the TAC attitude towards radar-guided SAMs thus: "I worked closely with the TAC shop across the hall from me at the Pentagon. I knew a lot of the guys there. They said they didn't need jamming pods to defeat the missiles, they would outfly them -- no sweat!"[24] One can only wonder how many fighter pilots who said "no sweat!" fell victim to North Vietnamese radar-guided SAMs during the air war in Vietnam. That lesson about the need for ECM had to be bought with blood.

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[22]TAC History, pp. 331-332, January-June 1957, K417.01, in AFHRA.

[23]Both quotes from Price, History of US EW, Vol II, pp. 144, 249.

[24]Ibid., p. 264.

CHAPTER TEN

REFLECTIONS

The Air Force's combat record during World War II clearly demonstrated the enormous effort that went into developing, deploying and successfully employing electronic warfare as a key element of the strategic aerial offensives against Germany and Japan. This study is based on the question whether or not the Air Force used the decade following World War II to advance this capability. The answer is mixed, neither a resounding yes nor an accusatory no, and the reasons for the mixture reveal much about the Air Force in its first decade.

It seems clear that as soon as the war ended the public and political pressure to demobilize as rapidly and completely as possible was irresistible, and any attempts to systematically and methodically codify the EW lessons of the war would have to be accomplished in the face of a constant hemorrhage of personnel and resources. The process could certainly have been managed better, but it is unlikely that it could have been done in anything like an orderly and systematic manner, even if plans for "after action" or "lessons learned" studies had been developed during the war. What made the situation worse was the unusual status of the Air Force's small cadre of EW experts, almost all of whom were relatively junior officers who were not part of the prewar Air Corps and as wartime technical experts were candidates for early return to civilian life. When the need to demobilize quickly arose, they were among the first officers to be mustered back to civilian life. The very informality of the personnel and ad hoc nature of the organization that enabled the wartime EW process to be so responsive to the combat situation also meant that when the wartime emergency was over the EW organization and process quickly fragmented. The few EW officers who remained in the Air Force during and after the demobilization spent their time literally keeping their heads above water; not until the entire Air Force began its overall rebuilding in 1947 was the EW program able to begin anew also. The impact of this was witnessed during the Korean War, when SAC B-29 bombers operating over North Korea were forced to use old World War II-era jammers and ECM equipment because new equipment was still in the R&D process. In part this was because the Air Force was unwilling to risk revealing its newest capabilities to Soviet intelligence, but it was also because in 1950-51 the Air Force had few new EW capabilities to risk revealing.

Two factors were of critical importance to the rebirth of EW in the Air Force during the first decade after World War II. The lesser of these was the publication of NSC 68 and the subsequent outbreak of the Korean War, which provided the political and psychological impetus to begin rebuilding the country's overall military capability. The resumption of combat operations in Korea, and the assumption or fear that war in Europe, war on a much larger, more terrible and threatening scale, might not be far behind, led to large increases in the defense budget and a concomitant increase in the resources allocated to EW.

This was especially true because of the first and more important factor in the rebirth of EW, the ascendancy of SAC and the vision of SAC's senior leadership, starting with General Curtis E. LeMay. Many, especially younger, Americans' perception of LeMay have unfortunately been shaped by his ill-advised entry into politics in the late 1960s. That side of LeMay misses a point crucial to this study: he was one of America's truly great combat leaders and operational air commanders. As head of the XXIst Bomber Command and chief architect of the great B-29 offensive against Japan he had direct knowledge of the significant role EW played in the defeat of the Japanese radar and night defenses, and he supported the tactical and technical improvement of those capabilities. When he took command of the Strategic Air Command in 1948 he carried this support forward.

Nothing better demonstrates LeMay's understanding of and support for EW than his willingness to delay production of the B-52, SAC's new jet bomber for the 50s and 60s (and 70s, 80s and 90s!) for nearly a year and a half, the time required to redesign the bomber and add a sixth crewmember, the electronic warfare officer. This decision, which LeMay willingly took to improve the combat capability of the new bomber, entailed a significant amount of technical risk and required an enormous amount of work rerouting much of the electrical system, installing equipment for the new crewmember (including an ejection seat), and countless other production details. Hand in hand with this were several key doctrinal and operational factors. The ECM Tactical Evaluation that LeMay sponsored marked a watershed in how the Air Force tested ECM equipment, evaluating it as an integrated weapon system rather than as isolated pieces of equipment. EW had a vital role in the SAC war plans of the period, and the tactical doctrine that guided the employment of aircraft was heavily shaped by the use of ECM to negate enemy defenses. EW was totally integrated into the SAC exercise and training program, to refine and test both personal and unit proficiency in the use of EW. SAC routinely ran exercises involving several dozen aircraft, all employing ECM as a critical part of the exercise. All of these factors illustrate how committed SAC was to maximizing its use of electronic warfare and electronic countermeasures to improve its warfighting capability.

This success story must be contrasted with TAC's failure to develop a useful EW capability and its attitudinal rejection of EW. Although there were certainly difficult hardware problems involved in trying to develop small, lightweight ECM devices for fighters and light-to-medium bombers, they were the lesser of two problems compared to convincing the mass of TAC's fighter pilots that they not only could use but might even require ECM. This organizational failure would come home with a vengeance in the 1960s. The inability to develop the "radar buster", precursor of today's "Wild Weasel", would cost TAC dearly in the years to come.

The diffidence with which TAC treated EW, and the support and promotion it received in SAC, was evidence of a conceptual failure within the Air Force. The element that had direct combat experience employing EW, LeMay and his senior staff at SAC, aggressively worked to improve the command's EW capability. They put resources into it, including personnel, aircraft, and budget, at a time when all three were in short supply. TAC, on the other hand, did not learn from the experiences of World War II or even Korea, and ignored the electronic revolution that was taking place. While TAC took full advantage of the technical revolutions in propulsion and firepower, arming itself with a jet force that had the capability to deliver atomic weapons, it left itself open to enemy radar-assisted air defenses and laid the seeds for crisis in Vietnam a decade later. This was despite an EW doctrine that was extremely prescient and could have significantly improved TAC's combat capability had it been followed. Perhaps the lesson is that regardless of how good a doctrine may be, if the fighting force is not imbued with and supportive of that doctrine it will not be successful in combat. The contrast between TAC's EW doctrine and how TAC failed to put that doctrine into practice reveals much about EW's real place in TAC. SAC saw the need and put its resources and trust in the new electronic weapon, with beneficial results that extended into the 1990s; TAC did not see it, and paid the price.

As mentioned earlier, there were organizational overtones and lessons to learn from this. The ad hoc nature of the World War II EW organization was well suited to providing a specific capability in response to an individual crisis, but when the crisis and war ended the ad hoc organization ended as well. Ad hoc groups are not well suited to meeting long-term needs, and not until the Air Force established an organization to manage the EW program would that program be able to make its full impact felt. This is related to a point made earlier that technological change takes place within an organizational setting that does impact, positively or negatively, the course of those changes. In the early 1950s the EW process was dominated by one element, SAC, that was aggressively seeking to improve its EW capability. Although this may have hampered the EW efforts of other Air Force organizations such as TAC or ADC, SAC's dominance of the EW process probably was an overall boon to the effort, since SAC was the biggest advocate and user of EW at this time.

A related issue involves the organizational placement of EW within the Air Force bureaucracy of the 1940s and 50s. EW traced its organizational roots back to Communications-Electronics, and its roots lay in turn with the Army's Signal Corps, which was in charge of developing communications and electronic equipment. A radar set was unquestionably a piece of electronic equipment, but although a radar *jammer* seemed to be just another piece of electronic gear it was in actuality far more: it was a *weapon*, as capable of directly harming the enemy as a bomb or bullet. This organizational arrangement worked adequately during World War II, in part because of the sense of urgency which permeated most activities, and in part because of how small the EW function was, *but it was not so successful afterwards*. An example of an organizational misassignment was the British Army's development of the Congreve rocket during the early 19th Century. The British Army assigned the rocket to the Royal Artillery. It was no surprise that the Royal Artillery, dominated by gunners wedded to traditional tube artillery, firmly opposed the rocket and eventually succeeded it killing its development. EW did not encounter this sort of outright opposition within the Air Force's Communications-Electronics organization, but it also was definitely "second cousin" within the organization. This had a significant impact at the cutting edge of the Air Force, the combat units, because the EW expertise was located within what was generally regarded as a technical support function instead of with the combat planners and operators. This seriously hampered the effective integration of EW into operational planning.

Organizational decisions need to be grounded in an analysis of how different organizations function; since the primary function of EW was combat operations it would have been more effective to have tied EW more closely to the operational and combat Air Force instead of Communications-Electronics. This would have had the added benefit of strengthening the institutional sponsorship of EW within the Air Force.

The Air Force did not make full use of the initial post-World War II decade to build on the capabilities it had developed and employed during the war. There were many reasons for this. Some, such as the relentless push during 1945-1947 towards demobilization, were beyond the control of the Air Force. The industrial base that had been built up to support EW during World War II was decimated, and only a few companies continued to do EW-related production. Some reasons, such as the lack of a procedural or institutional mechanism for insuring that the hard-bought lessons of combat were codified into doctrine, were entirely due to internal Air Force shortcomings. The last line of the Far East Air Force's "Report on the Korean War" is worth repeating: "We must conclude that these lessons were ignored, forgotten, couldn't be located, or were never documented--or if documented, were never disseminated."

In the four-plus decades since then the Air Force seems to have taken this message to heart. The speed with which the Air Force initiated the Gulf War Air Power Survey after the Gulf War of January-February 1991, and the on-going doctrinal development process embedded in the Air Force, are evidence that this particular lesson has been learned and the institutional mechanisms emplaced to prevent its recurrence. EW is no longer seen as merely an "add-on" capability that is the realm of a few technical specialists to be used or ignored as desired. Aerial warfare is now virtually dominated by EW, as evidenced by the conduct of the Gulf War. Maybe the Air Force will no longer have to spend men and airplanes to relearn combat lessons that it had already learned.

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At first blush it might seem that a topic so esoteric-sounding as "electronic warfare" would be scarce in source material, but such is not the case. Given the time frame covered by this study, the vast majority of applicable Air Force records had already been declassified or were rapidly downgraded upon review. Throughout, this study uses Air Force records that were originally unclassified, had already been downgraded because of the government's automatic review process, or were reviewed and declassified at the author's request.

This bibliography is designed to assist other researchers in locating and evaluating sources of possible interest to them and is organized into the following categories: Finding Aids; Primary Sources (Archives, Published Sources, Congressional Documents); and Secondary Sources (Books, Dissertations, Contractor Studies (e.g. RAND), Articles. Sources of particular importance or interest are highlighted.

Finding Aids

As a group, the several bibliographic studies published by the USAF, either by the Air Force Office of History or by Air University, are virtually indispensible. Paszek's Guide to Documentary Sources is especially valuable for research in primary sources, although it is in need of updating. This is true for most of these studies published by the USAF during the 1970s or earlier. The Declassified Documents finding aid published by Carrollton is invaluable for locating previously-classified documents now made available to the public.

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Primary Sources

Archives

Three primary archival collections were used in the research for this study. First and foremost was the vast collection of USAF records held by the Air Force Historical Research Agency (AFHRA) at Maxwell AFB, Alabama. Formerly known as the Albert F. Simpson Historical Research Center, the agency holds an enormous amount of documentary material on the USAF, dating back to World War I and before. When combined with the holdings of the Air University Library, Maxwell AFB's "academic circle" probably has the world's most extensive collection of material relating to military air power. Researchers cannot afford to ignore, however, the holdings of the National Archives and Records Service (NARS), which also holds a tremendous amount of material related to American military air power and the USAF. The chief difficulty with research in the NARS holdings is the daunting combination of massive holdings and skimpy indexing, which can necessitate poring through boxes of papers to find useful data. The Guide (see above) published by the NARS, in conjunction with Paszek's work, are key starting points in determining which record groups should be searched. The third archival collection especially pertinent to this study is that held by the Association of Old Crows: the US Electronic Warfare Association, which is located in Alexandria, Virginia, and maintains a collection of oral history interviews with dozens of people who have been active in all aspects of electronic warfare. This collection is not large but is tightly focused on EW, and provides information not available elsewhere. Various USAF organizations and commands have maintained their own archives and document collections, and several of these were useful in the research of this study. The archives of the Strategic Air Command (SAC) have been divided between the new Strategic Command, a joint organization still located at Offutt AFB, near Omaha, Nebraska, and the Air Force's new Air Combat Command (ACC) at Langley AFB, Virginia, which includes the merged Tactical Air Command (TAC) and SAC. The archives of the old Air Force Systems Command (AFSC), previously located at Andrews AFB, Maryland, have been transferred to the home of the new (or perhaps resurrected is a better word) Air Materiel Command, back in its old home at Wright-Patterson AFB, near Dayton, Ohio. Researchers would be advised to contact the history office at these organizations to determine the availability of materials. The following is a very brief synopsis of the key holdings of the AFHRA and NARS used in this study.

AFHRA

AFHRA's holdings are organized using a mixed filing system that is divided chronologically. Those documents that date from the start of the Korean War or later are identified with a K prefix. Thus, 5th Air Force records for the January-June 1950 period would be filed under 730.01, while those from July-December 1950 or later would be filed under K730.01. Other records are filed by organization; thus the 555th Fighter Squadron could be found as SQ-Fighter-555-History-May 1950, while the history of the 432rd Fighter Wing 'ould be found as K-Wing-Fighter-432-History-May 1951. Researchers using the AFHRA's holdings would be well advised to familiarize themselves with this system, both to locate known documents and as a research tool for locating other, unknown holdings.

HQ USAF, Director of Communications-Electronics, Electronic Systems Division, Electronic Warfare Branch; 143.01
HQ USAF, other records and documents; 168.01
Air Training Command; 220.01
Air University and subordinate schools; 239.01
Air Research and Development Command; 243.01
Wright Air Development Center; 243.011
Air Defense Command; 410.01
Strategic Air Command; 416.01
Tactical Air Command; 417.01
Far East Air Forces Bomber Command; 720.04
5th Air Force; 730.01

NARS

Record Group 341 contains documents pertaining to Headquarters USAF and includes over 7,000 linear feet of material. In 1963 Helene Brown, Olive Liebman, Mary Joe Minor, and Jessie Midkiff compiled a "Preliminary Inventory of the Records of HQ USAF", which was extremely helpful in narrowing the search process. The following were the most valuable sources of material within this vast collection:

Correspondence file of the Special Assistant to the Chief of Staff, USAF, relating to research and development 1951-53.
Deputy Chief of Staff/Development, Director of R&D, and sub-offices:
- Policy Group
- Strategic Air Group
- Electronics Division

Deputy Chief of Staff/Operations, Director of Communiations-Electronics
Deputy Chief of Staff/Materiel

Record Group 218 includes records of the Joint Chiefs of Staff, including JCS memoranda of policy pertaining to electronic warfare.

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Biography - Daniel T. Kuehl

Personal Data

Born 27 July 1949 in Erie, Pennsylvania. Graduated from Erie East High School in 1967. Married Susan D. Novet in April 1971; two daughters, Kimberly (age 20) and Dorian (age 9)

Education

- B.A. (history) from Allegheny College, Meadville, Pennsylvania, in June 1971
- M.A. (History) from Temple University, Philadelphia, Pennsylvania, in 1973
- M.A. (History) from Duke University, Durham, North Carolina, in 1988

Graduate of several USAF schools, including Squadron Officers School (1977), Air Command and Staff College (1981), and Air War College (1986).

Positions

Adjunct Faculty Instructor (History) for the University of Maryland (Overseas Division, 1973-74), and Troy State University in Montgomery (1976-77)

Currently chief of the Air Staff division supporting the Secretary of the Air Force's multi-volume analysis of the Gulf War of 1990-91, the *Gulf War Air Power Survey*.

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Contributor to Garland's pending Encyclopedia of World War II in Europe, (Garland Publishing Co., New York)