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A RAND NOTE

**Roles and Missions for Conventionally  
Armed Heavy Bombers—An Historical  
Perspective**

Dana J. Johnson

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**Roles and Missions for Conventionally  
Armed Heavy Bombers—An Historical  
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**Dana J. Johnson**

**Prepared for the  
United States Air Force**

**RAND**

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## Preface

This report was prepared as part of the RAND "Bomber Force Study." This study was sponsored originally by the Special Assistant for Strategic Modernization, Directorate of Strategic, Special Operations Forces (SOF), and Airlift Programs, Assistant Secretary of the Air Force for Modernization (SAF/AQQ-A). Offices of Collateral Responsibility included the Strategic Air Command, Plans Directorate (SAC/XP); the Air Force Center for Studies and Analysis (AF/CSA); and Headquarters, United States Air Force, Strategic Offensive Forces Division (AF/XOXFS). As a result of reorganization of the Air Staff, Maj Gen Robert M. Alexander, Director of Plans, Office of the Deputy Chief of Staff for Plans and Operations, became the sponsor of the study through its completion. He has since been succeeded by Maj Gen Howell Estes and later by Maj Gen John Lorber. Headquarters, United States Air Force, Strategic Planning Division (AF/XOXP) is coordinating completion and distribution of the study documentation. Research was performed in the Aerospace and Strategic Technology Program of Project AIR FORCE.

The purpose of this report is to gain insight from analysis of past campaigns of the military utility of conventionally armed heavy bombers and the practical realities of bomber operations. This study examines the employment of long-range bombers in alternative roles as illustrated in five historical campaigns: two associated with World War II, one with the Korean conflict, and two with the Vietnam War. To bring the analysis into current-day focus, the role of the B-52 in the Operation Desert Storm air campaign is briefly assessed. Finally, extensive operational details such as Linebacker II route maps are included in the appendices.

This study should be of use to military and civilian defense planners interested in long-range bombers, strategic modernization, arms control, cruise missiles, conventional power projection, air defense penetration, stealth technology, and advanced conventional munitions effectiveness.

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# Summary

## Introduction

Over the past few years the United States has found itself facing a transformation of the international security environment. This transformation carries a number of attendant challenges for U.S. military forces including a growing potential for Third World conflicts involving technologically sophisticated belligerents, increasing uncertainty about the availability of foreign basing for American forces, and an increasing reliance on long-range weapons platforms as conventional precision-strike weapons, supported by space systems and other means of long-haul communications, navigation, and surveillance. In parallel, force structures and associated budgets are being reduced, largely as a result of domestic pressures to cut spending and perceived changes in the threat posed by the nations of the former Soviet Union.

Against this backdrop, the U.S. Air Force has undertaken a review of existing and planned aerodynamic forces. Part of this review entails addressing the potential roles and missions that long-range conventionally armed bombers might play in supporting national objectives. Just as it is necessary to examine potential roles and missions for *future* aircraft, it is helpful to address the use of bombers in *past* campaigns. Accordingly, as part of a larger study on the future of aerodynamic forces, RAND undertook an historical assessment of the role of the heavy bomber in World War II, Korea, Vietnam, and most recently, Operation Desert Storm. The purpose of the assessment was *to gain insights from analysis of past campaigns of the military utility of conventionally armed heavy bombers and the operational realities of employing bombers*. The results of that assessment are given in this report. Based on alternative roles and missions, a set of historical cases was selected that encompasses the strategic bombing campaigns against Germany and Japan in World War II; the strategic bombing and air interdiction campaigns against North Korea; the close air support, air interdiction, and strategic bombing efforts during the Vietnam war; and the strategic bombardment and air interdiction aspects of the Gulf War air campaign.

In view of this purpose, this report focuses on *operational* concerns, that is, operational problems associated with mission planning, targeting, bomber attrition, and other operational factors. This report details the strategic bombing campaign conducted by the Eighth Air Force over Germany, the strategic bombing of Japan, and the role of the long-range bomber in Korea. It then

addresses two separate bomber operations in Vietnam: the defense of the Marine base at Khe Sanh in early 1968 and subsequent strategic bombing campaigns, particularly Linebacker II in December 1972. The aerial defense of Khe Sanh demonstrated the capability of the B-52 to perform air interdiction and close air support, while Linebacker II was representative of bomber employment in traditional offensive operations. Finally, the study briefly assesses the contribution of B-52s to the air war in the Gulf. While all cases were examples of joint operations and should be acknowledged as such, our focus here is on the role of the long-range bomber in these operations.

## Study Organization and Sources

This report has four sections and two appendices. Section 1 sets the theme and scope of the study and defines key terms, including "strategic bombardment," "air interdiction," and "close air support" within the context of force application, i.e., "bringing aerospace power to bear directly against surface targets." Section 2 identifies key war plans that set the foundation for the World War II bombing campaigns, examines those campaigns against Germany and Japan, and then addresses the role of the bomber in the Korean War. The third section focuses on the role of the B-52 in both the Vietnam War and Operation Desert Storm. Each case is analyzed from a set of perspectives:

- Background
- Mission planning, targeting, and coordination
- Operations and tactics
- Bomber attrition and losses
- Bombing results
- Effect on the prosecution of the war.

Section Four provides a summary comparison of the cases and offers some "lessons learned" on the contribution of the long range bomber in the historical cases addressed. Some caution is warranted in drawing direct comparisons across a 50-year time span at a level of operational detail that is very technology- or system-dependent; however, the many fundamental elements and similarities that recur in each case may provide insights for the future.

The appendices contain summary data on such items as sorties and losses for certain cases and route maps for Linebacker II, showing ingress and egress routes, times to and over the target, and support aircraft. In addition, a bibliography is provided.

Many official records, historical accounts, secondary sources, and RAND studies proved extremely valuable to this study. Reliance was placed on official histories published by the Air Force, including a number of Vietnam-era documents that were declassified during the project. Certain secondary sources provided both extensive and critical operational detail on Eighth Air Force operations. In addition, these works were supplemented by personal observations of Vietnam bomber operations. Finally, of the plethora of Gulf War-related documentation that have appeared since the end of the war, only a few (including a forthcoming RAND study) treat the air campaign exclusively; these sources were also used (albeit within the bounds of classification). Given the range of authoritative sources, it is not the intent here to rewrite history but to identify areas and issues of operational interest and relevance to the larger RAND study.

## **The Realities of Experience: Planning and Operations in World War II and Korea**

The thinking behind the development of the air war plans that governed the exploitation of bombers in World War II drew heavily from the development of air power doctrine, particularly strategic bombardment doctrine, in the Army's Air Corps Tactical School (ACTS) in the 1920s and 1930s. The doctrine focused on identifying a few critical national industries and networks, or systems, on which the state depended and whose destruction would cripple the state and break the enemy's will to fight. Such systems included electric power, transportation, fuel, food distribution, and steel manufacturing. Exploitation of the airplane to attack these systems meant that no nation was immune from attack and that the battlefield was no longer limited to armies; this strategy led to the belief that the airplane held the key to victory in modern warfare. These and other tenets of ACTS were to be included in the development and implementation of Air War Plans Division (AWPD) Plan 1 (September 1941), the blueprint for an air offensive against Germany; its successors were AWPD Plan 42 (August 1942), which planned for a possible eventuality of a two-front war against Germany and Japan, and the Combined Bomber Offensive (April 1943), which set forth a joint U.S.-U.K. air strategy against German military, industrial, and economic systems and to undermine German morale.

The implementation of the war plans in the European theater included establishing the Eighth Air Force to perform bombing operations from the United Kingdom against strategic targets in Germany and elsewhere in Europe. Early missions and targets were coordinated with the Royal Air Force (RAF) Bomber Command; however, as a result, an inherent doctrinal tension arose between the

RAF's emphasis on nighttime area attacks and the USAAF's focus on daylight, high-altitude, precision bombing by large formations of heavy bombers.

Mission planning, targeting, and coordination for the "Mighty Eighth" was complex, labor-intensive, and time-consuming. Targeting objectives were made consistent with the Combined Bomber Offensive (CBO). The principal operational factor affecting the mission, however, was weather, to the extent of determining the scope of the mission or whether it was even feasible. Other operational factors were the availability of crews and aircraft. Operations and tactics were characterized by the use of large bomber formations, believed to be the best approach to maximize delivery of weapons to the target and to increase bomber and crew survivability against the German Luftwaffe fighters. But the lack of long-range fighter escorts, continued efforts by the Luftwaffe to find allied bomber vulnerabilities, and lethal German flak defenses resulted in horrific losses for the Eighth, especially in raids against Schweinfurt in mid-October 1943. Other operationally related factors that served to increase bomber attrition included engine failures, propeller feathering problems, the loss of engine oil, and particularly devastating, mid-air collisions and accidental dropping of bombs on other aircraft resulting from the requirements of formation flying.

The daylight precision raids conducted by the Eighth required not only advanced systems such as the Norden bombsight and the automatic flight control equipment (AFCE) that linked bombsight and autopilot but also an experienced bombardier. The various bombing techniques developed to counter the effects of weather included radar-guided bombing, otherwise known as "Pathfinder," and grid bombing used in conjunction with smoke markers. Ultimately, however, bombing accuracy depended on both the weather and the skill of the bombardier. Conversely, poor intelligence and faulty assumptions about the German reconstitution capability diminished the success of the bombing raids. Consequently, the doctrine of strategic bombardment, as embodied by the Eighth Air Force, was not proven to be as decisive as was expected.

Strategic bombing proved to be much more effective against Japan. But this effectiveness was largely a result of a change in strategy—from selective precision targeting of industrial sites to incendiary mass attacks on Japanese cities. Japanese society and war-supporting industries were much more susceptible to the effects of incendiary attacks. As in Germany, however, the attacks were not successful in accomplishing the predictions of the advocates of air power—that bombing would break the will of the enemy. The Japanese population did not become demoralized.

The bombing campaign was viewed as a precursor to a planned invasion of the home islands. Because of the limited range of the B-29, a succession of beachheads had to be established in the Pacific from which to conduct raids on Japan. Beginning in 1944, industrial and urban targets, including aircraft and engine factories in Tokyo and Nagoya, were attacked from these island beachheads. In addition, countershipping efforts, such as aerial mining were undertaken and proved to be major contributors to the defeat of Japan.

The early raids entailed missions on the order of 12 to 14 hours, under hazardous conditions, with no margin for error on returning to base. The B-29s were forced to carry weight, primarily fuel, that far exceeded their design specifications. On the other hand, the bombers were met with little resistance, in sharp contrast to bomber operations in Europe. Operational problems experienced by the crews led to technological adaptations in gunnery equipment, stationkeeping by radar (for formation assembly and maintenance in heavy weather), and search and rescue capabilities.

Although the end of World War II and the onset of the Korean war were separated by less than five years, the U.S. military forces had been dramatically downsized during that period. The strategic bombing doctrine was reoriented from conventional to nuclear, with the expectation that now the atomic bomb could remedy the conventional bombing problems experienced during World War II. For many reasons, U.S. leadership misread the cues of the impending invasion of South Korea by the North, with the result that the number of forces required to defend South Korea was underestimated. Used in strategic (conventional) bombing and air interdiction, the Far Eastern Air Forces (FEAF) Bomber Command became the part of the American/United Nations' response to the invasion.

A short, almost leisurely, strategic bombing campaign was conducted against North Korean war-supporting and logistical systems beginning on 8 August 1950. This slow pace was partially a result of airspace congestion caused by the concurrent air interdiction campaign, which led to a staggered approach over the target and for the return to base. Weather was also a factor, not only inhibiting intelligence collection over targets but also largely determining bombing approaches for each mission. The bombing campaign was considered successful because of the lack of North Korean opposition and the skills of the crews.

The entry of China into the war in the fall of 1950 resulted in an emphasis on interdiction missions. Although North Korean rail and communication lines were attacked successfully, their almost immediate repair decreased the effectiveness of the campaign. Bomber losses also increased (eight bombers and

crews by mid-April 1951) with the interdiction campaign. Thus the diminished command strength was such that FEAF Bomber Command (BC) could not support more than 12 sorties per day. As a result, target priorities to airfields and ground support were changed.

To summarize, while the strategic bombing campaign against North Korean industrial and communications targets was fairly successful, the interdiction campaign—providing the bulk of FEAF BC efforts—was much less so. Air power was effective in supporting the early retreat against Chinese Communist forces. In general, however, bomber crews were not prepared by training or equipment to support the interdiction campaign effectively.

## **Realities Revisited: B-52 Operations in Vietnam and the Persian Gulf War**

Rather than addressing heavy bombers in general, this section focuses on the contribution of the B-52 specifically because of its longevity and to explore its roles in both wars, separated by two decades or more. The B-52s used in the Gulf are far more advanced than those used in Vietnam; although the airframe is the same, the avionics have been upgraded extensively.

Differing views of the role of air power in Vietnam led directly to the operational problems encountered in the historical cases addressed. For example, the strategic bombardment doctrine was to prove ineffective when applied to a rural culture since few industrial centers were to be attacked. For various reasons, a *de facto* functional and geographical division of labor developed among the air elements of each service in Vietnam. This division of labor led to the establishment of "route packages" over North Vietnam, with the allocation of effort split between the Air Force and the Navy. Finally, severe political constraints were placed on the use of strategic bombers, leading to mission planning and targeting being conducted by the Strategic Air Command in Omaha and closely monitored by Washington. Ultimately, operational procedures and tactics imposed by SAC Headquarters contributed to the heavy losses experienced in Linebacker II, since the predictability introduced into the missions allowed the enemy to employ his air defenses more effectively.

The Rolling Thunder (March 1965 to November 1968) and Linebacker I (spring 1972 to late October 1972) graduated bombing campaigns did not prove effective in deterring Viet Cong attacks. Bomber employment in the defense of the Marine base at Khe Sanh in early 1968, however, proved far more effective. In this instance B-52s were used in conjunction with tactical aircraft in close air support

and air interdiction roles in a sustained effort to disrupt the Tet Offensive and to blunt the attacks on the base. A total of 48 B-52s sorties—16 missions per day with three aircraft each over the target every 90 minutes—was devoted to Operation Niagara (the name given to the U.S. air response to the Tet Offensive).

As in the earlier cases examined, weather proved to be a critical operational factor. By this time, however, bombers possessed all-weather capabilities. Other operationally related factors concerned the control of artillery and fire support in areas immediately surrounding the Marine base. It was only by accident that the Marines found that bombing could be conducted at ranges much closer in proximity to the base than previously thought. Ultimately the B-52s could bomb within 1 kilometer of friendly positions with great effect.

The defense of Khe Sanh was successful largely because of the amount of resources devoted to the campaign. But it had the negative effect of tying up U.S. air assets for more than two months at a cost to other air operations elsewhere in the theater.

Linebacker II in late December 1972 focused on targets in and around Hanoi and Haiphong. It was initiated to bring the North Vietnamese back to the negotiating table so that the United States could exit the war in some sort of face-saving way. The campaign was conducted in three phases over an 11-day period against railroad yards, storage facilities, radio communication facilities, airfields, and surface-to-air-missile (SAM) sites (bridges were also targeted but not by B-52s).

As in Rolling Thunder and Linebacker I, mission planning, targeting, and coordination were affected by operational targeting and weaponeering decisions made in Omaha. Ingress and egress routes were planned, at least initially, with limited consideration of the air defense and SAM threat. Missions also were characterized by "compression" tactics and "press-on" rules of engagement, which did not allow mission flexibility. The compression tactics conducted for defense suppression reasons entailed flying three cells of three aircraft each against the same target area with up to a ten-minute separation between cells. Press-on rules of engagement (ROEs) meant that the aircraft were to continue to the target regardless of mechanical or other problems or if SAMs were encountered. These rules resulted in far fewer aborts than would have been expected in view of the number of aircraft involved in the operation. The prevailing collateral damage concerns were not only a source of crew frustration but also constrained aircraft survivability.

Poor weather conditions made the assessment of munitions' effectiveness and bomb damage difficult. The bombing results that were evident were demonstrated in the levels of damage achieved against rail and storage facilities.

On the other hand, Linebacker I inadvertently had encouraged the North to shift to truck movement and dispersal of storage sites. As for attrition rates, a remarkable fact is that no cases of attrition or accidents were caused by combat—in fact, *there were no accidents at all*. This fact has been attributed to the training the crews received for strategic nuclear missions. That training, however, did serve to unduly constrain bomber operations over the targets and contributed to the loss of 15 aircraft and crews.

During the air campaign of the Gulf War, the air-launched cruise missile (ALCM) B-52G was used in addition to the conventional B-52G. Much of its use, however, cannot be distinguished from the overall air campaign because the bombers were employed in tactical fashion rather than in a more autonomous or semiautonomous manner. Mission planning, targeting, and coordination was turned over to the theater air component commander, a radical departure from Vietnam. Missions were complicated by the few numbers of bases in the theater (for political reasons) and resulted in long sorties and a heavy burden on SAC to sustain the bomber force.

Other factors affecting bomber performance included a lack of readiness particularly in prepositioned spares, an unfamiliarity with joint operations (i.e., flying with other tactical and command and control aircraft), and avionics software deficiencies that affected bombing accuracies. The bombers flew at high altitudes rather than at the low altitudes for which the crews had trained. Finally, the inherent attributes of the bombers were not exploited or tested as fully as they might have been. Consequently, the contribution of B-52s to the successful outcome of the war cannot be ascertained definitively nor should this experience be taken as typical of future conventional bomber operations.

## Lessons Learned

Returning to the purpose of this study—to gain insights from analysis of past campaigns of the military utility of conventionally armed heavy bombers and the operational realities of employing bombers—some “lessons learned” are suggested by the preceding accounts of past bomber operations. These lessons lie in five areas: mission planning, targeting, and coordination; operations and tactics; bomber availability, attrition, and losses; bombing effectiveness; and effects on the prosecution of the war.

### *Mission Planning, Targeting, and Coordination*

Much of the mission planning and targeting for strategic bombing campaigns, such as those reviewed here, rest on key assumptions of what national elements are suitable for striking by a conventionally armed heavy bomber. The concepts developed by ACTS in the 1920s and 1930s provided the foundation behind the planning documents used for guiding bomber operations against Germany and Japan and emphasized industrial and war-supporting targets as key to undermining the enemy's will to fight. The results, however, were decidedly mixed. They were even more indecisive when applied to Korea and Vietnam, which were less industrialized than Germany and Japan. These observations, however, do not discount the utility of the bomber in performing antisubmarine warfare, countershipping, aerial mining, close air support, and battlefield air interdiction roles. Performing these alternative missions necessitated innovative or nontraditional mission planning and targeting as well as coordination with other services and units. It also implied a willingness on the part of the Air Force to put institutional interests aside to accomplish common strategic and tactical objectives. Given current trends toward more joint and combined campaigns involving the efforts, systems, and capabilities of all the services and other allies, the Air Force probably will find fewer opportunities to "go it alone" and increasingly will have to coordinate its mission planning with the other services and allies.

### *Operations and Tactics*

Throughout the cases addressed, operations and tactics consistently have been affected by both aircraft- and crew-related conditions over which the Air Force may have some or complete control and by physical or phenomenological conditions over which the Air Force may have little or no control. Weather falls into the latter category; while its effects have diminished relative to the capabilities of the airplane (such as radar), its impact is still significant. Newer technologies such as terrain-following guidance for air-launched missiles and space-based navigation should continue to diminish the impact of geographical and atmospheric conditions in the future.

Formation flying has been both an image and an operational necessity of strategic bombing operations. The introduction of electronic warfare, stealth, smart bombs, and other advanced technologies, however, make the necessity of formation flying less obvious today. Caution must be exercised in rigidly adhering to standardized operational procedures based on a nuclear orientation and existing training when planning responses to future regional contingencies.

Although the bomber crew size is now smaller, the duration of missions appears to be growing—given the diminishing availability of theater basing. Today the concern is about the capabilities of the crew members to perform their assigned missions in the face of possible extended range scenarios such as support in the future to Korea or Europe from CONUS bases.

### ***Bomber Availability, Attrition, and Losses***

Apart from obvious mechanical aspects, *bomber availability generally has been a function of perceived combat urgency.* While the stakes may have been different in each case, or in others in which the United States may have had an abundance of air power, nevertheless, each situation imposed some measure of perceived combat urgency. Consequently, operational procedures such as compression tactics or press-on rules of engagement became the norm. Common sense and combat necessity also dictated the devotion of more assets to the effort than mission planning would seem to warrant. This approach should be accounted for when allocating scarce resources or when diverting them from their primary roles for combat-related purposes.

Generally bomber attrition occurred as a result of mechanical and other noncombat related causes as well as to damage sustained in combat—not serious enough to cause a crash. These reasons probably will remain constant, despite the remarkable record of Linebacker II. Attrition and loss rates can be lowered or minimized through the use of innovative operational measures in conventional bombing, rather than applying traditional, i.e., strategic nuclear approaches. Detailed and complicated planning can bring favorable results and enhance crew survivability but, in turn, that depends on responsive and innovative training in conventional bombing.

### ***Bombing Effectiveness***

Historically, heavy bombers have been more successful in attacking area targets rather than point targets because of the necessity, driven by the threat, to bomb from high altitudes. Also, there was a lack of precision-guided weapons with sufficient accuracy to attack point targets. The introduction of ALCMs and smaller munitions, perhaps equipped with Global Positioning System (GPS) uplinks, into the conventional bomber inventory will change this scenario substantially. Proposed efforts to integrate advanced systems for information acquisition and management should assist in improving intelligence capabilities to support air operations. These improvements, in turn, should assist in

providing a better determination of the effectiveness of the bomber and its associated weapons in performing a variety of roles.

### *Effects on the Prosecution of the War*

Finally, the record of the long-range bomber in affecting the outcome of the conflicts assessed in this study has been mixed. Owing to either misinterpretations of intelligence or the lack of it, the effects of strategic bombing varied considerably in terms of their impacts on the leadership and population. In most cases it was more likely that enemy military forces became more demoralized from the bombing than did the civilian population. Furthermore, in most cases the enemy regime in power could maintain control over the populace, thus mitigating the effects of the campaign. Nevertheless, as was shown in Iraq, the psychological effects of the heavy bomber on those at the receiving end of its bombs cannot be discounted.

To conclude, the United States is faced with a transformation in the international security environment in ways never conceived by early air power advocates. Consequently, a potential exists for increasing reliance on long-range air-breathing weapons platforms to accomplish U.S. national objectives. The growth of new aerospace capabilities poses new opportunities for the evolution of the conventionally armed heavy bomber; yet care must be taken not to develop another associated "myth" that may lead to unrealistic expectations of what the bomber can achieve. The U.S. Air Force should be forewarned that budgetary and other pressures may not allow the advanced bomber to explore and demonstrate its potential adequately, which may directly impact the ability of the United States to pursue its national interests. It remains to be seen within the next few years where the line will fall between these new opportunities and unrealistic expectations.

## Acknowledgments

The author has benefited from many discussions with RAND colleagues Glenn Buchan, Dave Frelinger, Jim Quinlivan, Jim Winnefeld, and David Shlapak on bomber operations in general and the specific historical cases examined in this study. Chris Bowie and other members of the Secretary of the Air Force's Staff Group, and Lt Col Michael Wolfert, Air Force Space Command (AFSPACECOM), provided useful insights into the evolution of air power and the diverse roles that bombers have played in past campaigns. Maj John Graham, USAF (retired), gave extensive "real world" details on the Vietnam War's Linebacker II operations based on personal experience of flying missions from U-Tapao. Chris Bowie, Glenn Kent, and Carl Builder offered their valuable expertise and criticism on an earlier version of this study that proved very beneficial to its theme as well as to its substance. The historians at the Air Force Historical Research Agency, Maxwell AFB, and the Office of Air Force History, Bolling AFB, were also of great assistance in pointing out many historical sources available in both libraries as well as clarifying the historical events described herein. Furthermore, in the interim since the author's visit to Maxwell in 1990, many Corona Harvest and Project CHECO documents detailing bomber operations during the Vietnam War have been declassified by the Southeast Asia Declassification Group. These documents have opened up a wealth of information about B-52 operations and tactics during Linebacker II in particular that have proven very beneficial to accomplishing the objectives of this study. Nevertheless, the views expressed in this study are those of the author alone.

## Acronyms

AAA	antiaircraft artillery
AAF	Allied Air Forces
ABCCC	Airborne Battlefield Command and Control Center
ACTS	Air Corps Tactical School
AFB	Air Force Base
AFCE	automatic flight control equipment
ALCM	air-launched cruise missile
ATO	Air Tasking Order
AWPD	Air War Plans Division
BAI	battlefield air interdiction
BDA	bomb damage assessment
BG	Bombardment Group
C <sup>3</sup>	command, control, and communications
CBO	Combined Bomber Offensive
CENTAF	Central Command Air Forces
CENTCOM	U.S. Central Command
CINCFE	Commander in Chief, Far East
CINCPAC	Commander in Chief, Pacific Command
CINCPACAF	Commander in Chief, Pacific Air Forces
CINCPACFLT	Commander in Chief, Pacific Fleet
CINCSAC	Commander in Chief, Strategic Air Command
COMUSMACV	Commander, United States Military Assistance Command, Vietnam
CONUS	Continental United States
CPE	circular probable error
CTF-77	Carrier Task Force 77
DMZ	demilitarized zone
ECM	electronic countermeasures
EW	early warning
EWO	Electronic Warfare Officer

FAC	Forward Air Controller
FEAF	Far Eastern Air Forces
FEC	Far Eastern Command
GCA	ground-controlled approach
GCI	ground-controlled intercept
GHQ	General Headquarters
GPS	Global Positioning System
HE	high explosive
IB	incendiary bomb
IOC	initial operational capability
IP	initial point
JCS	Joint Chiefs of Staff
JFACC	Joint Force Air Component Commander
KIA	Killed in Action
LOC	lines of communication
LSL	lethal SAM line
MAF	Marine Amphibious Force
MIA	missing in action
MPI	mean points of impact
MRE	mean radial error
NVA	North Vietnamese Army
NVN	North Vietnam
PACAF	Pacific Air Forces
PFF	Pathfinder Force
POL	petroleum, oil, lubricants
PRC	People's Republic of China
PTT	post-target turn
RADCOM	radio communications
RAF	Royal Air Force
RDX	research department explosive
ROE	rules of engagement
ROK	Republic of Korea
RP	route package
SAC	Strategic Air Command

<b>SAM</b>	<b>surface-to-air missile</b>
<b>SOF</b>	<b>Special Operations Forces</b>
<b>TOT</b>	<b>time on target</b>
<b>USAF</b>	<b>United States Air Force</b>
<b>USMC</b>	<b>United States Marine Corps</b>
<b>USN</b>	<b>United States Navy</b>
<b>USSBS</b>	<b>United States Strategic Bombing Survey</b>
<b>VC</b>	<b>Viet Cong</b>

# 1. Introduction

Over the past several years, the United States has found itself facing a transformation of the global security environment that poses new challenges for American national interests and commitments. Numerous trends are evident in this transformation, many having implications for existing and future U.S. military force postures, particularly long-range aerodynamic forces. These trends include:

- A growing potential for Third World conflicts involving increasingly technologically sophisticated belligerents
- Heightened nationalist tensions and increasing political and economic destabilization of countries formerly under the control of the Soviet Union
- Growing uncertainty about the availability of foreign bases from which to project U.S. military power
- Correspondingly, American force structure changes and a growing reliance on long-range weapons platforms as conventional precision-strike weapons
- An increased dependence on space systems and other means of providing long-haul communications, navigation, and surveillance of regions where the United States is denied access
- Reductions in U.S. defense expenditures and forces in response to perceived changes in the threat.

In this context, the United States Air Force has undertaken a review of existing and planned aerodynamic forces. Apart from maintaining preparedness for strategic nuclear conflict, however remote a possibility it may seem, the Air Force and the Congress have a renewed interest in examining potential roles and missions for conventionally armed heavy bombers. Just as it is necessary to postulate potential roles and missions for *future* air forces based on national goals and objectives, it is advantageous to examine these same roles and missions from an *historical* context: how was the long-range heavy bomber used in past campaigns? By addressing this topic, perhaps insights can be gained that may provide additional guidance for future bomber force postures and operations.

Such an effort to examine and to assess bomber operations from an historical perspective was undertaken as a part of a larger RAND project on the future of aerodynamic forces. The results of that effort are given here. The purpose of the

assessment was *to gain insights from analysis of past campaigns of the military utility of conventionally armed heavy bombers and the operational realities of employing bombers*. Based on alternative roles and missions, a set of historical cases was selected that encompassed the strategic bombing campaigns of World War II against Germany and Japan; the strategic bombing and air interdiction campaigns against North Korea; the close air support, air interdiction, and strategic bombing efforts in the Vietnam War; and the strategic bombardment and air interdiction aspects of the air campaign against Iraq in Operation Desert Storm.

Bearing this purpose in mind, the focus of this report is on *operational* concerns—that is, operational problems associated with mission planning, targeting and target destruction, and bomber attrition. The report details the strategic bombing campaign conducted by the Eighth Air Force over Germany, the strategic bombing of Japan in the last stages of the Pacific war, and the role of the long-range bomber in the Korean conflict. In addition, two separate bomber operations during the Vietnam War and the events leading to them are examined: the defense of the Marine base at Khe Sanh, South Vietnam, in early 1968, and Linebacker II operations over North Vietnam in December 1972. The first operation, an example of the B-52 being used in air interdiction and close air support roles, represented the largest sustained, round-the-clock use of bombers in the Vietnam war up to that time. The second operation addresses the more traditional use of heavy bombers in offensive operations. Its significance lies in the greatest numbers of bomber aircraft and ordnance employed in a theater of operations since the Second World War. All cases were examples of joint operations (albeit, for World War II, not in the sense of jointness that is used today)—aircraft of not only the Air Force, but the Navy and the Marine Corps were also involved. Nevertheless, our focus is on the role of the long-range heavy bomber in these operations.

## Study Organization

This report has four sections. Section 1 introduces the reader to the historical cases to be addressed, gives the sources used during the analysis, and provides some key definitions that furnish the roles and mission context for the cases. The second section presents the World War II and Korean conflict cases, while the third section examines the role of the B-52 in both Vietnam and the Gulf War. Each historical case is addressed from the following perspectives:

- Background
- Mission planning, targeting, and coordination

- Operations and tactics
- Bomber attrition and losses
- Bombing results
- Effect on the prosecution of the war.

Section 4 is a summary comparison of each case and offers some insights and observations of the contribution of the conventionally armed heavy bomber to future air operations. Finally, the appendices include summary data on such items as sorties and losses for selected cases and route maps for Linebacker II. A bibliography is included after the appendices.

## Sources

This report takes particular advantage of the abundance of books and studies that are available in the open literature on air operations during World War II, Korea, and the Vietnam War. These sources include the official histories of the Army Air Forces in World War II<sup>1</sup> and those official histories published by Air University or the Office of Air Force History.<sup>2</sup> However, two volumes on the history of the Eighth Air Force were especially critical in providing a level of detail on operations that the official histories lack. These volumes are Roger A. Freeman's *The Mighty Eighth* (1991) and *The Mighty Eighth War Manual* (1991). For Vietnam in particular, studies including Brig Gen James McCarthy, Lt Col George Allison, and Col Robert Rayfield's *Linebacker II: A View From the Rock* (1979) and Karl Eschmann's *Linebacker: The Untold Story of the Air Raids Over North Vietnam* (1989), which are based on official sources, proved to be very beneficial to our analysis. Since this study was begun, many USAF Corona Harvest, Project CHECO and other official histories of the Vietnam War have been declassified by the Air Force Historical Research Agency and released to researchers. These documents open up a wealth of information about B-52 operations and tactics, for Linebacker in particular, that have proven very beneficial in accomplishing this study.

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<sup>1</sup>Craven, Wesley Frank, and James Lea Cate, eds., *The Army Air Forces in World War II*, especially Vol. I: *Plans and Early Operations January 1939 to August 1942*, University of Chicago Press, Chicago, IL, 1948, and Vol. V: *The Pacific: Matterhorn to Nagasaki June 1944 to August 1945*, University of Chicago Press, Chicago, IL, 1953.

<sup>2</sup>Such as Robert Futrell, *The United States Air Force in Korea 1950–1953*, 1983, John Schlight, *The United States Air Force in Southeast Asia; The War in South Vietnam: The Years of the Offensive, 1965–1968*, 1988, Bernard Nalty, *Air Power and the Fight for Khe Sanh*, 1986, and General William Momyer, *Air Power in Three Wars (WWII, Korea, Vietnam)*, 1978. (See Bibliography for full citations.)

Finally, in the past two years a plethora of reports and books has appeared on Operation Desert Storm. While many, including the official Department of Defense *Report to Congress on the Conduct of the Persian Gulf War*, examine the entire operation, only a few treat the air campaign exclusively. These sources include the *Gulf War Air Power Survey* report (draft, May 1993), James P. Coyne's *Airpower in the Gulf* (1992) and Richard P. Hallion's *Storm Over Iraq* (1992). The author also has the privilege of being a coauthor of an ongoing RAND study of the air campaign based on earlier RAND analyses conducted during and after the operation. Given these authoritative sources, it is not our intent to rewrite history but to identify areas and issues of operational interest and relevance to the larger RAND study of future strategic aerodynamic forces.

## Some Key Definitions

Before turning to the operations themselves, it is important to define "strategic bombardment," "air interdiction," and "close air support" as used in this report. The most current version of Air Force Manual 1-1 (March 1992) defines these terms within the context of force application:

**Force application brings aerospace power to bear directly against surface targets.** This role includes those missions that apply combat power against surface targets exclusive of missions whose objective is aerospace control. The objective of the strategic attack mission is to destroy or neutralize an enemy's war-sustaining capabilities or will to fight. Interdiction delays, disrupts, diverts, or destroys an enemy's military potential before it can be brought to bear against friendly forces. Close air support directly supports the surface commander by destroying or neutralizing enemy forces that are in proximity to friendly forces.<sup>3</sup>

These definitions provide the contextual approach for distinguishing among the historical cases. While there is a rich—and often divisive—historical legacy to these missions and to the development of air power doctrine, the scope of this document does not permit the detailed treatment that the legacy demands. The reader is urged to turn to the extensive literature on this subject that is widely available.

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<sup>3</sup>Air Force Manual 1-1, Vol. I, *Basic Aerospace Doctrine of the United States Air Force*, U.S. Department of the Air Force, Washington, D.C., March 1992, p. 6 (emphasis in original).

## 2. The Realities of Experience: Planning and Operations in World War II and Korea

### Prelude to War: Air War Planning Before and During World War II

The evolution of air power doctrine, especially the concept of strategic bombardment, was a product of a number of factors, notably geographic relationships, the American air experience in World War I, the universal reaction against trench warfare, and the emergence of new technologies. American air power (if it could be termed that, since combat exploitation of the airplane was in its infancy) was employed in World War I primarily in reconnaissance/observation and pursuit roles. In the postwar period, the efforts of a number of air power visionaries, notably Giulio Douhet and Billy Mitchell, served to highlight the distinctive characteristics of the airplane in altering the future course of warfare. Many debates, some of acrimonious nature, were conducted between the airmen of the Army and the mainstream Army and between the Army and the Navy over roles and responsibilities that might be assumed by the Army Air Corps.

The development of air power doctrine, and specifically its strategic bombardment emphasis, evolved at the Army's Air Corps Tactical School (ACTS) in the 1920s and 1930s and provided much of the doctrine behind the bombing campaigns conducted against Germany and Japan in World War II. In hindsight, the causal relationship between the implementation of strategic bombardment doctrine and the war's outcome was not as direct as touted by the air power theorists; nevertheless, the effects of those campaigns were substantial. In addition, the bomber served other useful operational roles not originally considered, such as support in finding and destroying German U-boats in the Atlantic.<sup>1</sup> In the Korea and Vietnam conflicts, the bomber was pressed into service in interdiction and close air support roles; however, its primary contribution was still considered to be strategic offensive/nuclear operations.

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<sup>1</sup>For analyses of the contribution of long range bombers to the Battle in the Atlantic, see Samuel Eliot Morison, *The Battle of the Atlantic, September 1939–May 1943. History of United States Naval Operations in World War II*, Vol. I, Little, Brown and Company, Boston, 1970, and *The Atlantic Battle Won, May 1943–May 1945. History of United States Naval Operations in World War II*, Vol. X, Little, Brown and Company, Boston, 1968; Michael Gannon, *Operation Drumbeat*, Harper Perennial, New York, 1991; and Ladislav Farago, *The Tenth Fleet*, Paperback Library, New York, 1962.

As envisioned by ACTS, analysis focused on the identification of a few critical national industries and networks, or systems, on which the modern industrial state depended and whose destruction would cripple the state. The tenets of ACTS are given below:

- Disruption/paralysis of a nation's major industrial and economic systems undermines the enemy's *capability* and *will* to fight
- These major industrial and economic systems contain critical points of leverage; bombs can be delivered with sufficient accuracy to destroy those points, thus breaking down the systems
- Massed air strike forces can penetrate air defenses without unacceptable losses and destroy selected targets
- Proper selection of vital targets and their destruction by air attack can lead to the fatal weakening of the enemy and victory through air power [note that "enemy" refers to an industrialized power]
- If enemy resistance persists, target enemy cities as a last resort with discriminate bombing against sensitive points.<sup>2</sup>

Based on an examination of the U.S. infrastructure, the types of national systems the ACTS theorists identified were electric power, transportation, fuel, food distribution, and steel manufacturing.<sup>3</sup> The use of the bomber against these systems meant that now entire nations were within the "combat zone" and no longer immune from attack. Furthermore, the outcome of a war would no longer be largely dependent on the success of the armies on the battlefield but also on the level of destruction that could be brought to bear on war-supporting industries. While populations were not to be targeted directly, the use of discriminate bombing on cities so as to make them untenable for living was advocated.<sup>4</sup> These concepts, all untested in practice until this time, became the foundation for the belief that the airplane alone of all modern weapons held the key to victory in modern warfare. Although the airplane could be used in support of land and sea forces and objectives, its primary utility would lie in projecting strategic offensive force against the enemy. Furthermore, to be effective, air power should be placed under the command of one airman at the highest levels of command. (This latter point was to bedevil Air Force relations

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<sup>2</sup>While many of these tenets are found in a variety of sources, the clearest statement from which the above is derived is found in Haywood S. Hansell, Jr., *The Strategic Air War against Germany and Japan: A Memoir*, Office of Air Force History, United States Air Force, Washington, D.C., 1986, pp. 7-10. For a longer and more detailed discussion of the ACTS tenets, see Craven and Cate, Vol. I, Chap. 2, pp. 51-52.

<sup>3</sup>Hansell, 1986, pp. 12-13. Hansell notes that at the time national policy forbade the study of foreign nations (i.e., gathering strategic intelligence); thus, the ACTS theorists were forced to make key doctrinal assumptions based on a model of the United States.

<sup>4</sup>Hansell, 1986, p. 14.

with its sister services even up until Operation Desert Storm.) Many of these concepts, however, ran counter to the official statement of Army doctrine—that the purpose of the Army Air Forces was to support the mission of the mobile army.<sup>5</sup>

The theories taught by the Air Corps Tactical School were not actually implemented until the onset of World War II and led to the formulation of plans and the acquisition of appropriate capabilities. The tenets became embodied in three separate war planning documents:

1. The Air War Plans Division (AWPD) Plan No. 1 (September 1941), which was the blueprint for an air offensive against Germany should the United States be drawn into a war<sup>6</sup>
2. The subsequent AWPD Plan No. 42, which identified target objectives and plans for a two-front air war against Germany and Japan (August 1942)
3. The Combined Bomber Offensive (April 1943), which outlined a joint U.S.-U.K. air strategy against the German military, industrial, and economic system to undermine German morale.<sup>7</sup>

Each of these plans laid out detailed levels of combat and support aircraft and personnel required to achieve the objectives. They also presaged the tremendous buildup of aircraft and personnel in England necessary to support the planned invasion of Europe in 1944.

AWPD-1 had the following objectives:

1. To wage a sustained air offensive against German military power, supplemented by air offensives against other regions under enemy control which contribute toward that power. . . .
2. To support a final offensive, if it becomes necessary to invade the Continent.
3. In addition, to conduct effective air operations in connection with hemisphere defense and a strategic defensive in the Far East.
4. The basic concept on which this plan is based lies in the application of air power for the breakdown of the industrial and economic structure of Germany. This conception involves the selection of a system of objectives

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<sup>5</sup>Hansell, 1986, p. 33.

<sup>6</sup>Before the Japanese attack on Pearl Harbor, AWPD-1 was an annex to a plan written by the Secretaries of War and the Navy and called *The Victory Program*. This program was a response to the president's call for "estimates of production required to defeat our potential enemies." After Pearl Harbor, only the Air Plan was considered feasible for implementation. See Hansell, 1986, p. 50; Craven and Cate, Vol. I, Chap 4.

<sup>7</sup>Hansell, 1986, pp. 72-73.

vital to the continued German war effort and to the means of livelihood of the German people, and *tenaciously concentrating all bombing* toward the destruction of those objectives. The most effective manner of conducting such a decisive offensive is by the destruction of precise objectives, at least initially. As German morale begins to crack, area bombing of civil concentrations may be effective.

5. It is improbable that a land invasion can be carried out against Germany proper within the next three years. If the air offensive is successful, then a land offensive may not be necessary.<sup>8</sup>

Key targeting objectives under AWPDP-1 consisted of:

1. Electric power: it was estimated that there were 50 key sites whose destruction would serve to critically disrupt German war-supporting industries.
2. Transportation: about 41 targets (marshalling yards, bridges, canal locks, and inland harbors) would cause the German transportation system to collapse.
3. Petroleum and synthetic oil: the German military machine was critically dependent on petroleum products.

While these represented primary objectives for the bombing effort, it was recognized that achieving Allied air superiority was crucial to being able to achieve these objectives; therefore, defeat of the Luftwaffe became the overriding priority.

Table 2.1 illustrates the numbers of combat and support aircraft and personnel that would be required to achieve the objectives (should the United States enter the war).

AWPDP-42 differed from AWPDP-1 in that it was an air war requirements plan that specified the resources and materiel required first to defeat Germany and second to support the effort to defeat Japan. Germany remained the priority, and target classes included German fighter aircraft assembly plants, bomber aircraft assembly plants, aero engine assembly plants, submarine yards, transportation targets, electric power system, synthetic oil plants, aluminum plants, and

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<sup>8</sup>Hansell, 1986, pp. 33-34. Emphasis in original. See also Craven and Cate, Vol. I, Chap. 4.

Table 2.1

**Air War Plans Division Plan No. 1: Air Forces Required for  
the Allied Offensive Against Germany**

<b>TOTAL AIR FORCE GROUPS REQUIRED</b>	
Heavy bombers	47
Very heavy bombers	24
Very long-range bombers	44
Fighters	54
Other aircraft	82
Total	251
<b>TOTAL MILITARY AIRCRAFT PRODUCTION REQUIRED</b> (Including unit equipment and initial reserves)	
<b>STRATEGIC FORCES</b>	
Heavy bombers	3,995
Very heavy bombers	2,040
Very long-range bombers	3,740
Fighters (escort)	2,000
TOTAL	11,775
<b>TACTICAL AND AIR DEFENSE FORCES</b>	
Bombers (medium, light, dive)	3,244
Fighters	6,748
Reconnaissance Aircraft	1,917
TOTAL	11,909
TRANSPORTS	1,064
TRAINERS	37,051
TOTAL COMBAT AND OPERATIONAL AIRCRAFT	24,748
TOTAL MILITARY AIRCRAFT	61,799
<b>TOTAL MILITARY PERSONNEL REQUIRED</b>	<b>2,118,625</b>

SOURCE: Hansell, 1986, p. 39.

NOTE: Heavy bombers = B-17, B-24

Very heavy bombers = B-29, B-32

Very long-range bombers = B-36 (necessary if Britain collapsed)

Other aircraft = primarily ground support

Once war had begun, it would be necessary to replace the combat units (24,748 total combat and operational aircraft) every five months to account for combat attrition. This plan would require the production of approximately 59,400 combat aircraft per year.

synthetic rubber plants.<sup>9</sup> Once the air effort against Japan was to begin, the assumption was that the campaign would be similar to that against Germany and that the strategic objective would be to destroy the Japanese people's will to wage war by destroying Japan's war-supporting industries and systems. The targets for Japan identified by AWPD-42 included:

<sup>9</sup>Hansell, 1986, pp. 58-59.

- Aircraft engine plants
- Submarine yards
- Naval and commercial bases
- Alumina and aluminum plants
- Iron and steel
- Oil
- Chemical plants
- Rubber factories.<sup>10</sup>

This list ignored two key targets: the Japanese electric power system and the transportation system. The former was assumed to be invulnerable because it was believed to be produced at small hydroelectric power plants operating independently from each other.

Thus, the distribution system was ignored. In the belief of one author, this error was costly for the Allies.<sup>11</sup>

Finally, the Combined Bomber Offensive (CBO) was a joint effort between the British Bomber Command and the American Eighth Air Force that took as its guidance the "Casablanca Directive"—a sustained air offensive against Germany, which was approved at the Casablanca Conference of January 1943. The CBO acknowledged the different tactical doctrines of the two air services (British night area bombing to affect economic and social systems and American selective daylight bombing using both bombers and fighters). While operating relatively independently of each other, they would mutually support the larger strategic objective of fatally weakening Nazi Germany.<sup>12</sup>

Targeting objectives for the CBO (code name: Pointblank) included: German submarine construction yards, the German aircraft industry, transportation, oil plants, and other war-supporting industry targets.<sup>13</sup> The German electric power system was included in the latter category. Nineteen primary target systems were identified. Again the destruction of the Luftwaffe, particularly the fighter, was designated an intermediate objective necessary to achieve the larger objectives of the Allies. The CBO identified four phases of increasing levels of Allied air capabilities:

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<sup>10</sup>Hansell, 1986, p. 60.

<sup>11</sup>Hansell, 1986, p. 60.

<sup>12</sup>Hansell, 1986, p. 73.

<sup>13</sup>Hansell, 1986, pp. 72-73.

- Phase One: 800 U.S. heavy bombers delivered to the U.K. by July 1943; depth of penetration limited to the range of escort fighters, with the exception of attacking the ball-bearing factory at Schweinfurt
- Phase Two: 1192 U.S. heavy bombers delivered to the U.K. by October 1943; depth of penetration: 400 miles from bases in the U.K.
- Phase Three: 1746 U.S. heavy bombers delivered to the U.K. by January 1944; depth of penetration: 500 miles
- Phase Four: 2702 U.S. heavy bombers delivered to the U.K. by June 1944; depth of penetration only limited by the operating radius of the bombers.<sup>14</sup>

Subsequently, in February 1944 the CBO was emphasizing German military, industrial, and economic systems as primary targets, and specifically the single-engine and twin-engine airframe and component production and the ball-bearing industry. (Since at that point the U-boat campaign had been defeated or largely neutralized, submarine construction yards and bases were eliminated from the target list.) The change in focus of the CBO set the stage for "Big Week" that same February in which an all-out offensive was conducted to destroy the Luftwaffe Fighter Command by destroying its fighter factories in Stuttgart, Regensburg, Schweinfurt, Leipzig, and other cities. The horrific losses experienced during "Big Week" severely tested strategic bombardment doctrine and concepts, but the objective was considered by Allied commanders to be critical to the success of the planned invasion of Europe later that year.

## Strategic Bombardment: The Strategic Bombing of Germany<sup>15</sup>

### *Background*

This subsection addresses World War II bomber operations from the perspective of the Eighth Air Force. While other numbered air forces performed offensive operations against the Axis, the record of the "Mighty Eighth" in implementing the concept of strategic bombing is the focus of our analysis. One word of caution is necessary, however: in this document it is not possible to detail every bombing operation that the Eighth undertook. Rather, our emphasis is on

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<sup>14</sup>Hansell, 1986, p. 76.

<sup>15</sup>Discussions of USAAF bombing operations in this section by necessity are based on two accounts of the Eighth Air Force: Roger Freeman's *The Mighty Eighth* and *The Mighty Eighth War Manual* (both published by Motorbooks International, Osceola, WI, 1991). These books are the best sources of 8AF operations and tactics available for the amount of detailed information they contain. The official history of the USAAF in World War II by Craven and Cate also was used heavily for the assessment of the bombing campaigns over Germany and Japan.

understanding heavy bomber operations, from mission planning to operations and tactics, bomber attrition and losses, and bombing results. Certain operations are highlighted briefly, such as the raids on Schweinfurt and Regensburg in the late summer and fall of 1943, which stand as testimonies to the fallacy of strategic bombing doctrine as it was performed in reality.

The Eighth Air Force was established on 2 January 1942 to perform bombing operations from the British Isles against strategic targets in the European theater. Its operational mode of employment was daylight high-altitude precision bombing by large formations of heavy bombers. Targets were enemy industrial and other vital installations whose destruction would severely weaken the Nazi war machine. American air power advocates believed that the use of the heavy bomber against Germany thus might forestall the need for lengthy offensive ground operations.<sup>16</sup> On the other hand, many within the Allied leadership felt that the use of strategic bombing was but a prelude to the expected invasion of the continent. By April 1943, the strength of the 8AF in Britain was planned to be 60 combat groups, comprised of 17 heavy, 10 medium, and 6 light bomber, 7 observation, 12 fighter, and 8 transport groups, for a total of about 3500 aircraft—a deployment size that would overwhelm the existing British airfields, maintenance, and supply depot capabilities. The backbone of the 8AF was to be the long-range heavy bomber, specifically the B-17F “Flying Fortress” and the B-24 “Liberator.” These aircraft were to be supported by fighters, such as the P-38F “Lightning” and the P-39D “Aircobra,” and by transports, such as the C-47 “Skytrain.” Command headquarters were set up at a girls’ school near High Wycombe in East Anglia, and efforts to achieve command operational readiness were begun. Few of the combat crews had flown at high altitudes, on oxygen, or in formation. Gunners were woefully inaccurate (that is, if they had operated a turret or shot at aerial targets at all), and radio operators were inadequately trained. The rapidity of the mobilization effort was the culprit, and extensive ground training, supported by intensive flying, was instituted.<sup>17</sup> By necessity, much of the training and other activities were modeled closely after RAF methods of operation but later were tailored to meet the specific needs of the Eighth.

Early missions and their targets were coordinated with the RAF Bomber Command and emphasized submarine building and port facilities, aircraft factories, repair depots, and other munitions facilities and lines of communication.<sup>18</sup> While the first few missions met with relatively little or no resistance, subsequent missions in the fall of 1942 were countered increasingly by

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<sup>16</sup>Freeman, *The Mighty Eighth*, p. 2.

<sup>17</sup>Freeman, *The Mighty Eighth*, pp. 4, 11.

<sup>18</sup>Freeman, *The Mighty Eighth*, p. 16.

Luftwaffe fighters. The biggest raid up to that time was against the Fives-Lille steel works in Belgium on 9 October. One hundred and eight heavy bombers, plus seven on diversion, were dispatched, a force not to be surpassed in size for six months. While they did demonstrate that enemy airspace could be penetrated in daylight and that moderate losses could be handled, the outcome of the raid was testimony to the relative inexperience of the crews as reflected in the inaccurate bombing of the targets and in the details of some of the losses.<sup>19</sup>

### *Mission Planning, Targeting, and Coordination*<sup>20</sup>

Mission planning, targeting, and coordination for the Eighth Air Force's bomber operations was complex, labor intensive, and time consuming. Campaign and mission planning were initiated at the headquarters of the 8th Air Force located at High Wycombe (codename: Pinetree), England, and devolved into mission operations planning at the Division, wing, and group levels below. Targeting objectives were set consistent with the objectives of the CBO directives. The principal controlling factor for mission planning and operations, however, was weather. Before the introduction of radar, weather conditions had to be good at both the target sites and at the bases from which attacks would be launched. The former was necessary because of the Eighth's reliance on visual bombing, while the latter was required for the bomber forces to gather in formation before heading to their targets.<sup>21</sup> After radar was introduced, weather became less of a factor, since targets with distinctive topography could be attacked under adverse conditions. Nevertheless, given the available technology and other conditions for the duration of the war, weather was probably the key element in determining the scope of a mission or if a mission was even feasible. The availability of crews and aircraft also affected planning.

Meetings to assess weather conditions were held among the senior operations officers three times daily: at 1015, 1600, and 2200 hours. If conditions were favorable, the Deputy Commander of Operations or his assistant would select targets from the priority list. Final decisions concerning the operation were made at the 2200-hour meeting and were incorporated into a Field Order. However, the three Bomb Division headquarters, the Combat Wings, and subordinate groups<sup>22</sup> would have been alerted to the possibility of the operation early on, after the first conference at 1015. Thus they had enough lead time to plan their

<sup>19</sup>Freeman, *The Mighty Eighth*, pp. 18–19.

<sup>20</sup>This discussion is drawn from Freeman, *The Mighty Eighth War Manual* (hereafter cited as *War Manual*), pp. 7–10.

<sup>21</sup>This situation was compounded by the airspace congestion over East Anglia during the winter of 1942–1943 while aircraft were being deployed from the United States to England.

<sup>22</sup>The focus of USAAF organization was the group, which was usually composed of three or four squadrons.

operations based on the coordination, targeting, and ordnance requirements generated by Pinetree. Targeting and ordnance specialists at the Bomb Division headquarters analyzed the targets specifically assigned to their groups, determined mean points of impact (MPIs), calculated aircraft and bomb types and tonnages needed, aircraft routes, times, and altitudes, and arranged for fighter support from the Eighth Fighter Command, all before receiving the formal Field Order. This information was passed to the combat wing headquarters via teletype, which was the primary means of communicating operational details. Then the combat wing headquarters could produce plans for their groups (usually three groups per wing). These plans were concerned with operational matters, for the wing HQ would act as the controlling authority during the actual operation.

At the group level, notification of the impending mission was received on a scrambler telephone, usually in the late afternoon or early evening of the day before the mission if the scale of the mission was large or in the early morning hours if the force was small. Key officers and section heads were informed by a simple "Mission Alert" message which told them that a Field Order was coming on the teleprinter. Depending on the time of day, it could be up to one hour before the arrival of preliminary information for that Field Order. Information received in advance of the Field Order provided the number of aircraft, bomb and fuel loads for the mission. The operations officers would make any last minute changes to the crew and aircraft status boards from this information. The standard practice concerning squadron availability was to stand down on every fourth mission unless higher orders or insufficient numbers of crews in the other three squadrons prevailed. Rotation among lead crews also was the practice.

The Intelligence Section (S-2) of each group was responsible for maintaining target files and all intelligence used to brief officers and air crews. It also maintained maps, photographs, and other media necessary for navigators and bombardiers. Based on this information and weather reports, route maps were plotted by the navigators with grease pencils or cotton thread on wall maps. Similarly, building on information received from the navigator's office, intelligence, and weather officers, the group bombardier's office determined target conditions and computed bombsight settings for attack altitudes.

Finally, the Field Order was received from Eighth Air Force headquarters, sometimes up to seven or eight hours after the initial teletype message. In addition to bomb load, it included the all-important "Zero Hour," a reference point for mission launch that allowed for the coordination within and among the groups for bomber assembly and formation before launch. Backtracking from Zero Hour, assembly was planned to begin, at a minimum, one hour before Zero Hour; 10 to 15 minutes for marshalling and taxiing; 10 to 15 minutes for engine

starting and warm-up; 10 minutes for “stations” (crew in aircraft); one hour minimum for readiness (crews at aircraft); one hour minimum for main briefings; one hour before briefings for breakfast; and 30 minutes before breakfast for crew wakeup. Separate Field Orders also were received from the Division and wing levels, each covering operations at a more detailed level. In the meantime, other support activities were begun, such as the loading of aircraft bomb bays and defensive gunnery by ordnance and armament crews, and preflight aircraft engineering. Combat crew briefings were conducted, and last-minute details particular to specific functions (e.g., gunners, radio operators) were gathered and assessed. Finally, the mission was launched.

### *Operations and Tactics*<sup>23</sup>

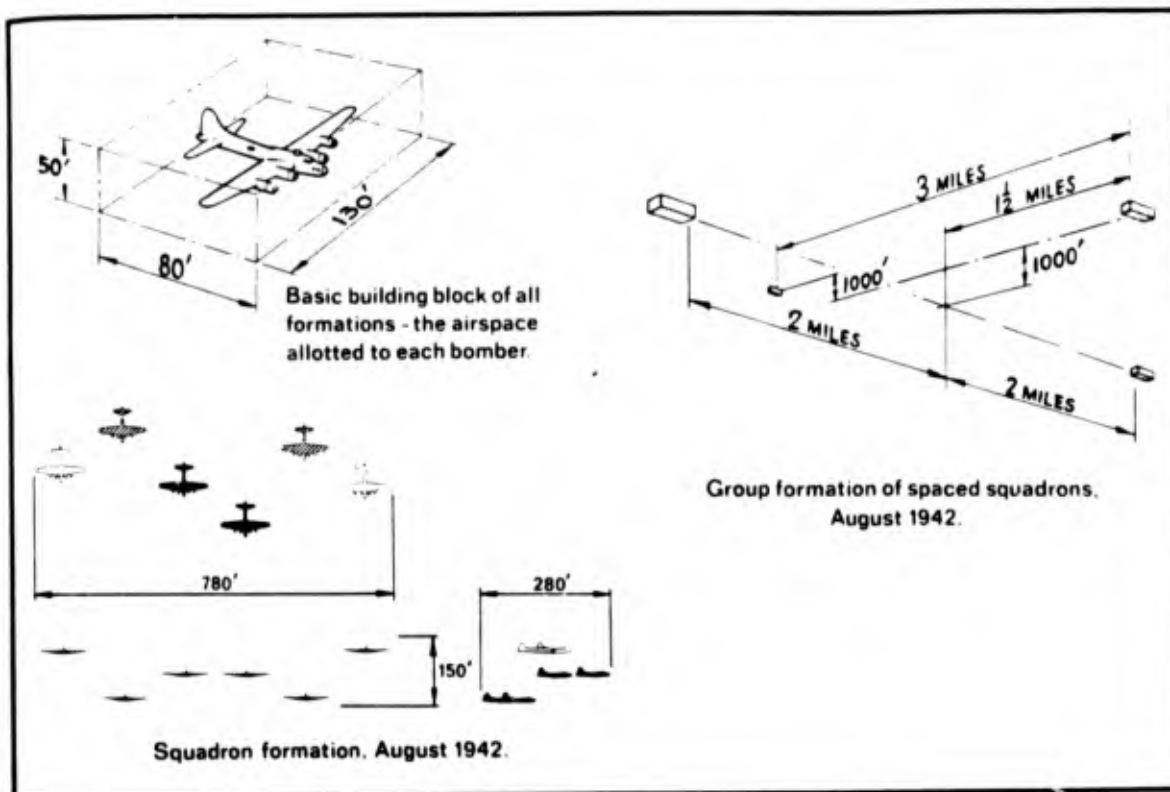
Just before takeoff, the Group Operations Officer was on hand in the control tower to monitor the takeoff and ensure that no problems delayed the mission. If emergencies did occur, he was responsible for remedying the situation, such as assigning other runways in case a crash or some other mishap occurred on takeoff. Maintaining the mission schedule was critical. There were intervals of 30 or 45 seconds between individual aircraft takeoffs, and he had to ensure that timing was not disrupted. The bombers carried “war emergency loads,” which meant they were fully laden (up to a gross weight of 65,000 pounds for the B-17F).

Once aloft, bomber formation took place generally at altitudes between 5,000 and 10,000 feet but sometimes up to 20,000 feet if clouds were a problem at the lower altitudes. Achieving formation was a complicated procedure so as to minimize the possibility of midair collision. Squadron formations comprised of two-, three-, or four three-aircraft elements were formed at varying altitudes and were separated by 400 to 500 feet. Group formations consisted of three squadrons with a high squadron on the right and a low squadron on the left, both trailing the lead squadron. Over time formations changed to offset enemy countermeasures, but the basic units remained the same. Examples of bomber formations are shown in Figures 2.1 through 2.3. The pattern of these formations was felt to be the best approach for both offensive reasons—the mass delivery of bombs on the target—and defensive ones—the massing of the bombers’ defensive firepower against the threat from fighter interceptions.

Often “war-weary”<sup>24</sup> combat aircraft were repainted in group colors and used as lead aircraft for assembly. They did not participate in the missions but returned

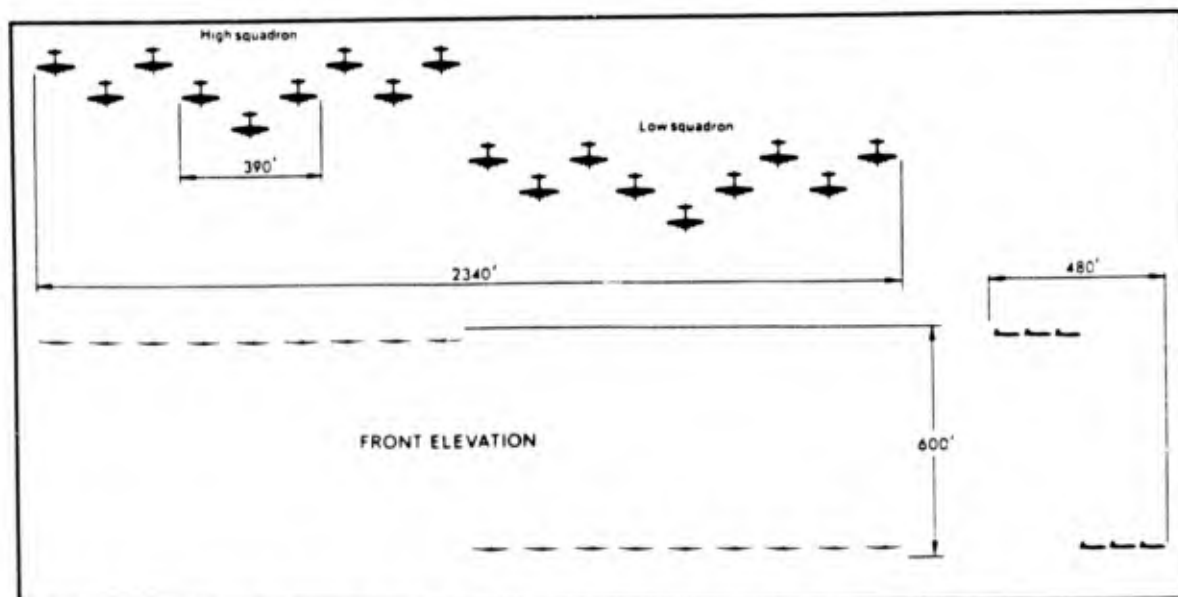
<sup>23</sup> Again, this section draws heavily from Freeman’s *War Manual*, pp. 17–32.

<sup>24</sup> These planes either amassed a great number of flying hours or had sufficient battle damage to restrict them to local flying, (Freeman, *The Mighty Eighth*, p. 201).



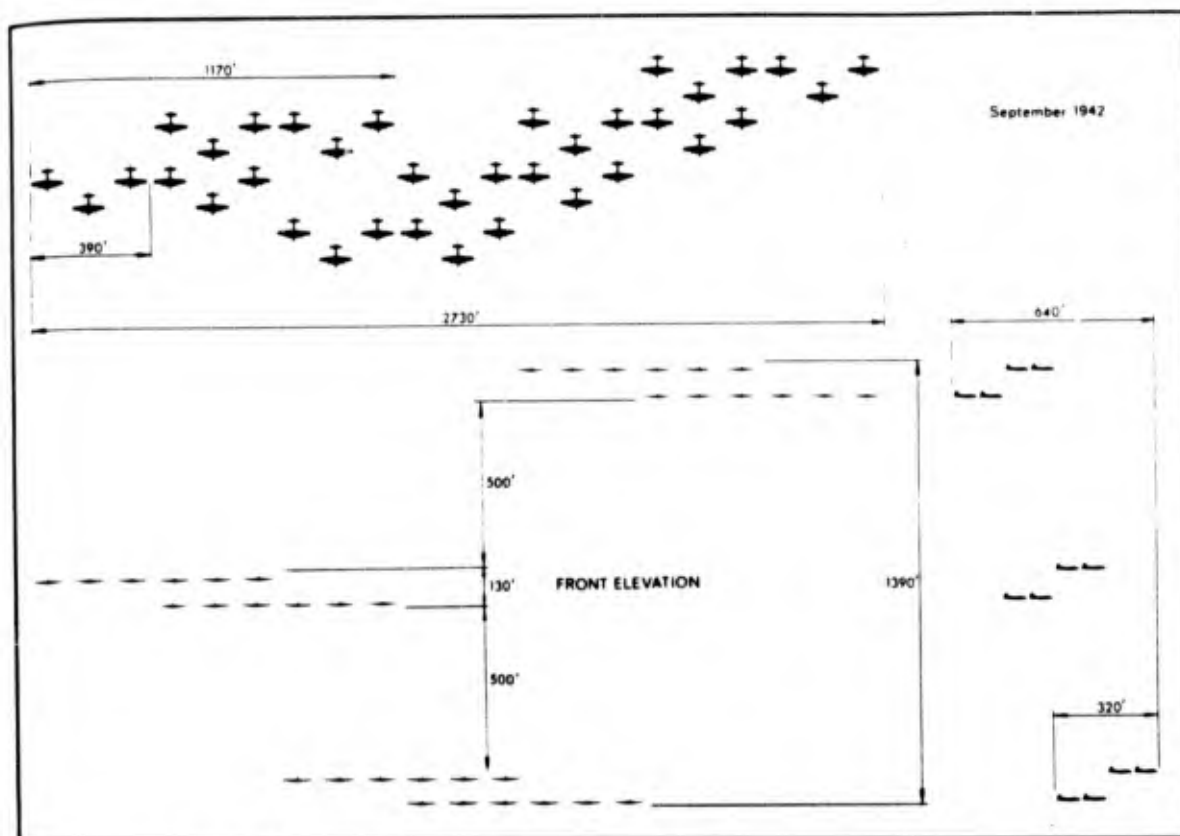
SOURCE: Freeman, *The Mighty Eighth War Manual*, p.39.

Figure 2.1—Basic Squadron Formation



SOURCE: Freeman, *The Mighty Eighth War Manual*, p.39.

Figure 2.2—18-Aircraft Group Formation



SOURCE: Freeman, *The Mighty Eighth War Manual*, p.41.

Figure 2.3—36-Aircraft Group Formation

to their bases after the formation was completed. Other formation aids included two types of radio beacons, known as "Splashers" and "Bunchers," that (unlike aircraft) could be used in almost any kind of weather. Splashers were medium frequency radio beacons with three to four transmitters at each site, each operating at different frequencies but pulsing the same call sign. Bunchers would be positioned on or close to the home base and would transmit a Morse signal that could be picked up by a bomber up to 15 miles from the base. The navigational radio beacon known as *Gee* also was used to maintain aircraft position, particularly if visual fixes were not available.<sup>25</sup> Flying to the combat wing assembly point began once group assembly was complete. Arrival times and altitudes were specified for each group and had to be followed precisely, given the numbers of aircraft involved—upward of 1000 for some missions—and the formations to be accomplished. As difficult as this procedure was to accomplish in clear air, it could become even more complicated by weather and winds, not to mention the turbulence caused by the leading aircraft. Division

<sup>25</sup>*Gee* had a range of up to 200 miles.

assembly followed wing assembly by about 20 minutes and would be formed at altitudes of 15,000 to 20,000 feet, depending on the altitude needed at penetration of enemy airspace to avoid antiaircraft fire.

If all divisions were headed to the same set of targets, then a single bomber stream would be formed to make it easier on the fighter escorts. Generally, enemy targets would be attacked at altitudes ranging from 24,000 to 27,000 feet for B-17s and 20,000 to 24,000 feet for B-24s, except when special targets and safety considerations allowed the use of lower altitudes.

Spare aircraft were also deployed to cover those aircraft aborting for mechanical or other reasons:

Until late April 1944 it was policy for each group to despatch three or four "spares"—bombers which took off and assembled as a high element to the high squadron and filled in any places in the group formation vacated by aircraft forced to "abort" by mechanical or other failures. If at the English coast there was no requirement for a spare, the aircraft concerned returned to home base. From late April 1944 a change of policy required all aircraft taking off for a mission to complete it, thus eliminating the spares status. Crews of any aborting aircraft—and there were usually several that returned to base early—were interrogated by an Operations Officer. Deliberately contrived abortives were rare. Nevertheless, all early returners came under a thorough scrutiny to ensure that there was a legitimate reason.<sup>26</sup>

Routes to the initial point (IP)<sup>27</sup> were rarely straight but were varied to deceive enemy fighters that had operational limits of under two hours aloft. The exploitation of the bomber stream approach also limited the fighter's ability to attack bombers in modes other than "hit and away passes." Because of the necessity to stay in formation, however, an individual bomber could only conduct up and down maneuvers to avoid fighter interceptions.<sup>28</sup> Once at the IP, a turn toward the target was made at between 30 and 45 degrees to allow for better positioning of groups and squadrons to make the run at the target. As a result of several maneuvers, the three groups would be separated by about two miles and on slightly different courses, but they converged at the target. Later in the war these maneuvers were changed to facilitate all groups passing directly in trail on the target, with an average of five miles apart. Chaff (bundles of foil strips) might be dropped by the waist gunner before and over a target so as to

<sup>26</sup>Freeman, *War Manual*, p. 21.

<sup>27</sup>The Initial Point was the point at which the run to the target was begun.

<sup>28</sup>Martin Caidin's account of the Schweinfurt raid in October 1943 describes the futility of evasive action in formation: "Jinking' is all we can possibly do—moving suddenly a few feet up or down. Even that serves only to disturb the aim of our gunners, and we are just as apt to jink into a burst as to avoid it. Its only accomplishment is to give some mental relief to the crew. The men feel we are at least doing *something*." *Black Thursday*, p. 126.

confuse enemy radars. Also, during the run over the target the bombardier in the lead aircraft of each formation was responsible for controlling the aircraft and providing range and deflection of the target.

In aircraft outfitted with a strike camera, bomb damage assessment (BDA) was done automatically after being designated by the bombardier. The camera took five to six pictures at six- to ten-second intervals. After returning to base, the film was developed and then assessed by intelligence officers to plot the group's strike pattern on the target. Other BDAs consisted of after-action reports given by the crews at debriefings after they returned from the mission. These reports covered observations of the target, enemy fighter interceptions, flak, weather, aircraft in distress, and other topics. After synthesizing the crew debriefings, a single report was sent to Pinetree via teleprinter, followed later by annexes with more detailed analyses. These would provide the basis for assessing the level of damage achieved and determining whether a revisit of the target would be necessary.

### *Schweinfurt and Regensburg*

By early 1943, American bomber forces were sufficiently built up in England that precision-oriented daylight bombing raids could be considered at force strengths of 200 bombers or more. However, early attacks on Bremen were met with stiff resistance from German fighters; out of the 115 bombers in the raid, 16 were shot down (13.9-percent loss rate) and 46 were damaged (40 percent). Nevertheless, the Commander of the Eighth Air Force, Lt Gen Ira C. Eaker,<sup>29</sup> and many of his senior commanders believed that a force of 300 or more bombers would be sufficient to attack any target in Germany with less than 4 percent losses.<sup>30</sup>

During the summer of 1943, several attacks were made against Bremen, Kiel, and Huls; again, losses were between 6.7 and 11.4 percent, primarily as a result of the lack of fighter escort. With the installation of drop tanks on P-47s in July, fighter escort contributed to lessening the numbers of losses. In several instances, however, the strength of the 8th Air Force fell below 300, and the raids were halted. Thus the Germans could rebuild their damaged industries, and production eventually reached peak levels.

In August 1943, in what became one of the most famous and costly raids of the war, Lt Gen Eaker sent his bombers against Schweinfurt and Regensburg. The

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<sup>29</sup>Lt Gen Eaker was Commander of the "Mighty Eighth" from 1 December 1942 to 5 January 1944. He was preceded by Maj Gen Carl A. "Tooey" Spaatz (5 May 1942 to 30 November 1942) and succeeded by Lt Gen James H. Doolittle (6 January 1944 to 9 May 1945). See Freeman, *The Mighty Eighth*, p. 282.

<sup>30</sup>Murray, p. 170.

objectives were to destroy the ball-bearing plants at Schweinfurt and the Messerschmitt complex at Regensburg that produced German fighters. These strikes were necessary to achieve the air superiority required to accomplish other strategic objectives. A total force of 376 bombers was dispatched; of that total, 315 dropped 724 tons of bombs.<sup>31</sup> Unknown to the Allies, the German air defense was at its peak strength. Of the two formations, the Schweinfurt group lost 36 out of 230 bombers, while the Regensburg group lost 24 of 146 (in actuality the number of the latter was higher, because 20 damaged aircraft were left in North Africa).<sup>32</sup> The loss of so many bombers in one day reduced the Eighth's operational strength by 10.3 percent of aircraft and 17.5 percent of crews. It was not until that October that the Eighth returned to Schweinfurt.<sup>33</sup>

In October, the Eighth Air Force conducted massive raids over a one-week period, with the following results:

1. 8 October: 399 bombers were sent against Bremen and Vegesack; 357 struck their targets, 30 were shot down, 26 received major damage, and 150 were slightly damaged.
2. 9 October: 378 bombers were sent, of which 352 hit Gdynia, Danzig, Marienburg, and Anklam; 28 were shot down.
3. 10 October: 236 bombers hit Munster; 30 were shot down.<sup>34</sup>

The raid on Schweinfurt on 14 October 1943, "Black Thursday," was by far the worst, however. Tables 2.2 through 2.4 provide the numbers of aircraft and crews, and the casualty figures from the 1st and 3d Air Divisions dispatched against Schweinfurt on 14 October. In essence, *for a total of 12 minutes over the target*, the Eighth Air Force lost 65 bombers out of a total of 291 dispatched, and 639 crewmen were killed, wounded, or missing in action. While these losses were disastrous—and unacceptable—for the Allies, the effect on the German fighter defense was equally bad, if not worse. The German ball-bearing industry suffered severe damage but was quickly repaired, particularly since the bombing effort was halted temporarily. (The raids against the ball-bearing plants are summarized in Table 2.5.) All in all, the Schweinfurt raid in October signaled the death knell of the prewar doctrinal fallacy of unescorted bombing. The active use of drop tanks, the emergence of the P-51 Mustang, and massive bomber reinforcements from the United States gave the added edge to the Allied air offensive, and by June 1944 the Luftwaffe was essentially neutralized.

<sup>31</sup>Caidin, Martin, *Black Thursday*, Bantam Books, NY, 1981, pp. 22–23.

<sup>32</sup>Murray, pp. 171–173.

<sup>33</sup>Murray, p. 173.

<sup>34</sup>Caidin, p. 39.

Table 2.2

**Air Task Forces Dispatched to Schweinfurt on 14 October 1943 by the 1st and 3d  
Bombardment Divisions: 1st Air Division**

Group	Base	Type of Aircraft	Number Dispatched				
91st	Bassingbourne	B-17	11				
92d	Alconbury (Podington)	B-17	19				
303d	Molesworth	B-17	19				
305th	Chelveston	B-17	16				
306th	Thurleigh	B-17	18				
351st	Polebrook	B-17	16				
379th	Kimbolton	B-17	17				
381st	Ridgewell	B-17	17				
384th	Grafton Underwood	B-17	16				
<b>Total</b>			<b>149</b>				

Group	Failed to Bomb <sup>a</sup>	Failed to Bomb <sup>b</sup>	Attacked	Lost	KIA	Wounded	MIA
91st	4	0	7	1	0	2	10
92d	1	5	13	6+1 <sup>c</sup>	1	4	60
303d	0	1	18	1+1 <sup>c</sup>	0	5	11
305th	1	12	3	13	0	3	130
306th	2	11	5	10	0	2	100
351st	3	3	10	1	0	5	10
379th	0	0	17	6	0	3	60
381st	2	0	15	1	0	3	10
384th	3	0	13	6+3 <sup>c</sup>	0	2	60
<b>Totals</b>	<b>16</b>	<b>32</b>	<b>101</b>	<b>45<sup>c</sup></b>	<b>1</b>	<b>29</b>	<b>451</b>

SOURCE: Caidin, *Black Thursday*, p. 231.

<sup>a</sup>For mechanical or equipment reasons

<sup>b</sup>For all other reasons

<sup>c</sup>Total losses were 50 B-17s. In addition to 45 lost in battle: one B-17 of 92d Group crash-landed at Alden Maston; one B-17 of 303d Group crashed near Riseley, crew bailed out; one B-17 of 384th Group crashed near Blatherwycke, crew bailed out; and two B-17s of 384th Group abandoned over England, crews bailed out. Of the returning bombers in 1st Bombardment Division, 63 were damaged.

### ***Bomber Attrition and Losses***

Not only were bombers lost in enemy action, they also suffered from other noncombat forms of attrition including mechanical problems such as engine failures, propeller feathering problems, and loss of engine oil.<sup>35</sup> Other flying-related attrition was caused by midair collisions (generally in cloud cover or when assembling for formation) and crashes on takeoffs and landings. Pilot error (generally because of inexperience) was the most common reason for the

<sup>35</sup>The loss of oil meant the loss of the hydraulic fluid, which in turn prevented the pilot from feathering a malfunctioning engine's airscrew. This problem was particularly worrisome in the B-17, which did not have an auxiliary oil supply system, and the B-24. Because the problem was not identified until repatriated and evading crews were debriefed, it took almost one year to develop and install an engine sump standby pipe in the B-17. Freeman, *The Mighty Eighth*, p. 103.

Table 2.3

**Air Task Forces Dispatched to Schweinfurt on 14 October 1943 by the 1st and 3d Bombardment Divisions: 3d Air Division**

Group	Base	Type of Aircraft	Number Dispatched
94th	Bury Saint Edmunds	B-17	21
95th	Horsham Saint Faith	B-17	18
96th	Grafton Underwood	B-17	41
100th	Thorpe Abbots	B-17	8
385th	Great Ashfield	B-17	21
388th	Knettisham	B-17	18
390th	Framlingham	B-17	15
<b>Total</b>			<b>142</b>

Group	Failed to Bomb <sup>a</sup>	Failed to Bomb <sup>b</sup>	Attacked	Lost	KIA	Wounded	MIA
94th	0	0	21	6	1	2	50
95th	2	0	16	1	0	0	13
96th	6	3	32	7	2	5	70
100th	0	0	8	0	0	0	0
385th	1	0	20	0	1	2	0
388th	1	1	16	0	0	1	0
390th	0	0	15	1	0	1	10
<b>Totals</b>	<b>10</b>	<b>4</b>	<b>128</b>	<b>15</b>	<b>4</b>	<b>11</b>	<b>143</b>

SOURCE: Caidin, *Black Thursday*, p. 234.

<sup>a</sup>For mechanical or equipment reasons

<sup>b</sup>For all other reasons. Of the returning bombers in the 3d Bombardment Division, 79 were damaged.

Table 2.4

**Summary Totals for Schweinfurt, 14 October 1943**

- First wave of B-17s struck Schweinfurt on bomb run from 1439 to 1445 hours from altitude of 21,000 to 24,000 feet
- Second wave of B-17s struck Schweinfurt on bomb run from 1451 to 1457 hours from altitude of 21,000 to 24,000 feet
- Casualties
  - 5 crew members KIA
  - 10 crew members seriously wounded
  - 33 crew members slightly wounded
  - 594 crew members MIA
- Aircraft
  - 40 B-17s lost from various causes; exact reasons unidentified
  - 2 B-17s lost from flak; positive identification
  - 18 B-17s lost from fighters; positive identification
  - 5 B-17s lost in England on return
- Bombs expended
  - 228 B-17s attacking Schweinfurt dropped a total of:
  - 450 1000-lb high-explosive bombs
  - 663 500-lb high-explosive bombs
  - 1751 100-lb incendiary bombs
- Ammunition
  - 697,828 rounds:
  - 1st Air Division expended 321,126 rounds .50-caliber ammunition
  - 3d Air Division expended 376,702 rounds .50-caliber ammunition

SOURCE: Caidin, *Black Thursday*, p. 235.

**Table 2.5**  
**Bombing Effort by Air Forces Against the German**  
**Ball-Bearing Industry**

	8th AF	15th AF	RAF	Total
Precision Raids	16	8	16	40
Sorties	2,409	668	938	4,015
Total Tonnage	6,457	1,868	3,824	12,149
HEs Dropped	17,993	5,951	1,814	25,758
Tons of HE	4,744	1,631	1,615	7,990
IBs Dropped	28,548	2,263	569,070	599,881
Tons of IB	1,713	237	2,209	4,159
Aircraft Lost	190	20	55	265
Aircraft Damaged	1,219	45	50	1,314
Area Raids	4	1	6	11
Sorties	294	87	2,529	2,910
Total Tonnage	681	261	9,812	10,754
HEs Dropped	2,542	1,044	7,131	10,717
Tons of HE	495	261	5,462	6,218
IBs Dropped	2,534	0	1,729,679	1,732,213
Tons of IB	186	0	4,350	4,536

SOURCE: David MacIsaac, ed., *The United States Strategic Bombing Survey*, Volume III, "The German Anti-Friction Bearings Industry, European Report No. 53," Garland Publishing, Inc., New York, 1976, Table 10, p. 34.

NOTE: 13 raids made by less than 10 planes each

ACRONYMS: HE = high explosive; IB = incendiary bomb

collisions. Another cause of attrition resulted from the necessities of formation flying: dropping bombs accidentally on other aircraft that had changed their position during evasive maneuvers. Many aircraft that made it home were too badly damaged to repair.

Many aircraft that were designated "war-weary" were used in other roles, such as ambulances, target tugs, and liaison transports. More often they were repainted in bright colors and designated as assembly ships (but more likely known as "Forming Ships," "Circus Leaders," or "Judas Goats"). All armament was removed except for a large supply of marker flares, then lights were added on the sides and the roof in the shape of the group identification numbers. The paint schemes consisted of gaudy stripes, checkerboards or polka dots, and probably could be considered the most bizarre ever put on warplanes.<sup>36</sup>

Another use for these older aircraft was in the experimental Project Aphrodite. This program was begun in June 1944 in response to the German development and employment of the V-1 flying bomb and V-2 rocket against Britain. The bombers were stripped of armament and armor, filled with the maximum amount of explosives (approximately 20,000 pounds of a combination of research department explosives (RDX), high explosives (HE), and aluminum powder),

<sup>36</sup>Freeman, *The Mighty Eighth*, pp. 128-129.

fitted with radio equipment, and guided by a “mother” ship into a target. In essence they became guided missiles. Unfortunately, the few launched against V-sites in the Pas de Calais area did little damage. Several others blew up in England, causing great damage (not to mention much consternation and fear among the local inhabitants).<sup>37</sup>

One factor that had a direct bearing on the effort to minimize combat losses in the raids was the lack of Allied fighter escort with sufficient range. Early in the bombing campaign, existing Allied fighter capabilities were insufficient to provide adequate escort to the bomber formations; drop tanks were not added to extend the range of P-38s and P-47s until mid-1943. Without adequate protection, the bombers were both constrained in the range of targets they could attack and left to defend themselves along their attack routes against an extremely capable enemy. The delay in getting fighters with extended range capabilities was caused somewhat by the prevailing attitudes among some in the senior Army Air Forces (AAF) leadership that stemmed from their days at ACTS: that massed bombers could always get through enemy air defenses to reach their targets. Lack of fighter escort had an obvious impact on bomber survival rate. Figure 2.4 illustrates the sortie loss rate for the Eighth Air Force from August

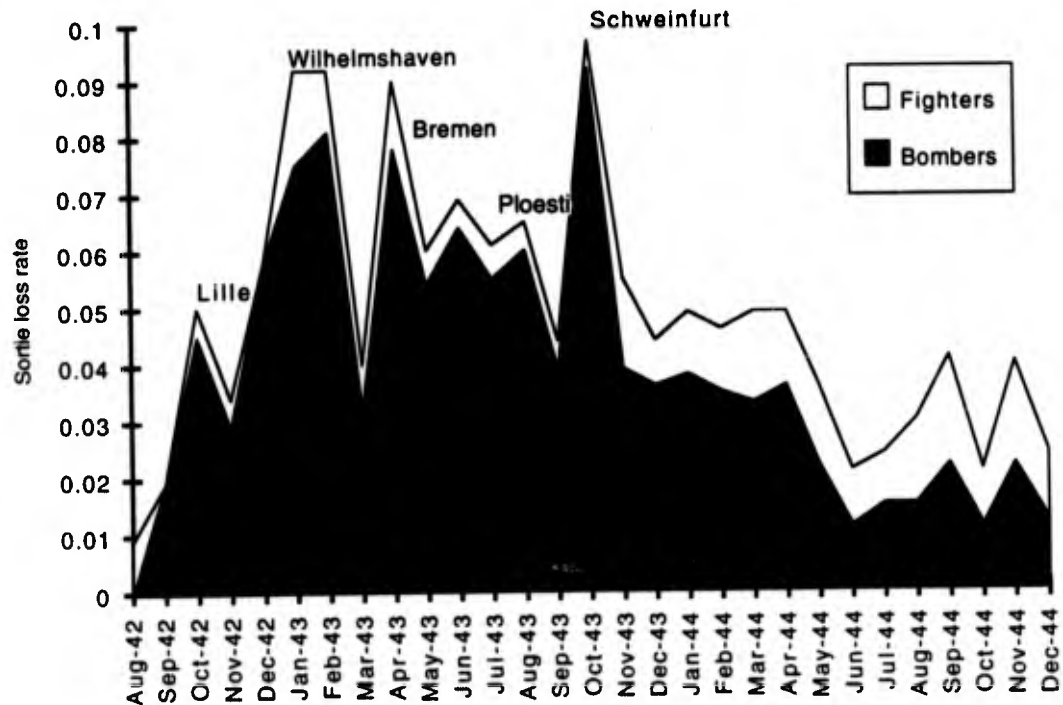


Figure 2.4—Eighth Air Force Sortie/Loss Rate

<sup>37</sup>Freeman, *The Mighty Eighth*, pp. 172–173; *War Manual*, pp. 162–163.

1942 through December 1944. (Table A.2 is a summary that gives percentages by month.)

*Flak.* Flak, for many aircrews, was their worst nightmare, even more than Luftwaffe fighters.<sup>38</sup> The Germans devoted enormous resources to the development and employment of improved flak capabilities, using about one million men and women to man the gun emplacements around key facilities in Germany and France. By the summer and fall of 1944, the Germans had improved their flak defenses, particularly around their oil installations and partly in response to their declining control of the skies. New gun site organizations and new employment tactics greatly increased the threat to the Allied bomber formations. The 88 mm guns were positioned in groups of 12, 16, 18, or 24 and fired in salvos that had a shotgun effect on the bombers. The 105 and 128 mm guns were positioned in groups of 12 or 4, respectively. This configuration enabled firepower to be centralized more effectively. Since the guns were now able to reach altitudes of 30,000 feet, the bombers could not escape by flying higher as they had with earlier flak. Apart from actually hitting the bombers, the Germans believed the flak decreased the effectiveness of the bomber raids by 25 to 33 percent.<sup>39</sup> Allied countermeasures included jamming of radars at the gun emplacements, the release of chaff to saturate the radars, and experiments in changing formation tactics; in principle, however, flak was unavoidable.

*Enemy fighter tactics:* While bomber formations had the advantage of massed defensive firepower, the German Luftwaffe continued to experiment with finding their vulnerabilities. In both the Flying Fortress and the Liberator, the aircraft nose was the most vulnerable point; thus the Luftwaffe focused on flying frontal attacks on the formations. One tactic consisted of eight fighters in a line abreast turning into the attack three to five miles ahead of the bombers; after the attack, they would dive below the bombers and attack the next formation in line, thus maximizing their time aloft. However, the limited evasive flying, or jinking, that the bombers could do in formation was fairly effective in spoiling the fighter's aim.

### ***Bombing Results***

As mentioned earlier, the U.S. approach to bombing was daylight precision raids, in contrast to the RAF's approach of nighttime area bombing. Successful bombing precision required not only technically advanced systems such as the

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<sup>38</sup>Fear and concern over flak were illustrated by the names given some bombers by their crews: *Flak Eater*, *Flak Wolf*, *Flak Dodger*, *Flak Magnet*, *Ole Flak Sack*, *Mrs. Aldaflak*, etc. Men who became "flak happy" were sent to a "flak home" to rest before resuming their tour. Freeman, *The Mighty Eighth*, p. 177.

<sup>39</sup>Freeman, *The Mighty Eighth*, pp. 137–139, 176.

Norden bombsight<sup>40</sup> and the automatic flight control equipment (AFCE) that linked bombsight and autopilot but also an experienced bombardier. While visual bombing approaches and equipment remained essentially the same throughout the war, bombing techniques to deal with overcast bombing evolved over time and became more advanced as new systems were introduced into the inventory. Radar-guided bombing, sometimes called "Blind Bombing" or "Overcast Bombing" became Pathfinder Force (PFF). "Pathfinder" techniques involved the use of specially trained crews and aircraft outfitted with the H2S, *Oboe*, H2X, or Micro-H radar and *Gee-H* navigation equipment and was used as lead aircraft in formations.<sup>41</sup> Grid bombing (a grid overlaid on a map to counter enemy smoke screens) and smoke markers as signals as to where to drop the bombs also were used extensively. Despite these aids, bombing accuracy varied and was ultimately dependent on both the weather and the skill of the individual bombardier.

Despite the number of aircraft and bombs sent against the Reich, their cumulative effect was not as severe as might have been expected because of the inaccuracy of the bombing (largely technology- and weather-dependent) and an underestimation of the German reconstitution ability. A severe handicap to the bombing campaign lay in the lack of intelligence and understanding about the German industrial dispersion and recovery effort. What intelligence the Allies had was predicated largely on faulty assumptions about the ability of German industry, especially the ball-bearing industry, to recover from the mass raids of 1943 and 1944. Although efforts were made to repair the damage inflicted by the early bomber raids, the German leadership decided to initiate a program of plant dispersal. Between November 1943 and August 1944, thirty-two new sites were built for the ball-bearing industry alone.<sup>42</sup> As the United States Strategic Bombing Survey noted:

The first lesson of the German experience is the indispensability of adequate and firm economic intelligence on the location and output of plants. The Allies knew exactly the anatomy of the industry in 1943 and early 1944, and their attacks on 90–95 per cent of the facilities were responsible for a 50 per cent drop in production by April 1944. By October 1944 the factories we considered worth attacking represented only 20 per cent of the industry's output, and bombing had little effect. In July we had known of only one dispersal plant, and we had falsely identified the product of that one. In early 1945 we knew the names of a dozen dispersal

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<sup>40</sup>The Norden bombsight, an analog computer, computed bomb ballistics geometry using airspeed, altitude, drift and heading data provided by the bombardier. See David A. Anderton, *History of the U.S. Air Force*, Military Press, New York, 1981, pp. 72–74.

<sup>41</sup>See Freeman, *War Manual*, pp. 46–52 for detailed discussions of various methods of overcast bombing.

<sup>42</sup>MacIsaac, David, ed., *The United States Strategic Bombing Survey*, Vol. III, "The German Anti-Friction Bearings Industry (European Report No. 53)," Garland Publishing, Inc., New York, 1976, p. 43 (hereafter cited as USSBS, Vol. III).

sites, but confused store-rooms with productive units, major factories with minor ones, assembly points with machine shops; and we were deceived by the false names used by the enemy for his new plants. . . .<sup>43</sup>

### *Effects on the Prosecution of the War*

Effects of the bombing on the ball-bearing industry have been noted. The effect on the morale of the German people, however, is also of interest for its implications for the tenets of air power. The Strategic Bombing Survey found that every German experienced either direct or indirect effects from the bombing (including shortages of food, water, electricity, or other impact on living conditions). Bombing severely depressed the German population, causing defeatism and apathy; however, it did not stiffen morale or lead to uprisings against the Nazi regime (primarily because of the extreme control exerted by the Nazi government through terror, propaganda, and other techniques). The survey showed that continuous heavy bombing of the same areas did not produce decreases in morale proportional to the amount of bombing. Consequently, the survey concluded that lighter but more widely distributed bombing would have obtained the maximum effect on morale rather than concentrated heavy bombing in limited areas.<sup>44</sup>

Consequently, the doctrine of strategic bombardment, of which the Eighth Air Force was the embodiment, was not proven to be as decisive as was expected. This is not to discount the effect of the bombing raids, but the virtues of unescorted daylight precision bombing in bringing an enemy nation to its knees were shown by the realities of operational experience to be limited.

## **Strategic Bombardment: The Strategic Bombing of Japan**

### *Background*

The introduction of the B-29 "Superfortress" into the inventory late in the war meant that the United States could exploit its long-range capabilities to conduct an air offensive against the Japanese home islands. Planning for the effort was focused on developing an air campaign characterized by selective precision targeting that would support an eventual invasion of the Japanese home islands. After that campaign was initiated, however, the decision was made to initiate incendiary attacks of Japanese cities. Much of the rationale for this change in

<sup>43</sup>USSBS, Vol. III, p. 20.

<sup>44</sup>MacIsaac, David, *The United States Strategic Bombing Survey*, Vol. IV, "The Effects of Strategic Bombing on German Morale," Vol. I, May 1947, Garland Publishing, Inc., New York, 1976, p. 1 (hereafter cited as USSBS, Vol. IV).

doctrine stemmed from an evolution in thinking in the European theater coupled with a growing availability of resources and a desire to influence the postwar situation.<sup>45</sup> To some air power proponents, this decision represented a regressive step from the improvements in precision bombing both over Germany and Japan. Nevertheless, both approaches severely affected the ability of the Japanese government and people to continue the war effort.

To secure an unconditional surrender from the Japanese, the strategic bombing of Japan was designed to focus on two efforts: (1) industrial and urban area targeting and (2) countershipping via aerial mining. Targeting objectives for the former emphasized specific aircraft and engine factories. As with Germany, the Japanese fighter aircraft industry, e.g., aircraft and engine factories, bases, and fuel depots, was deemed to be the primary target in order to secure air superiority and ultimately, air supremacy over Japan. Also like Germany, the distances to the targets stretched the capabilities of the bombers and escort fighters; therefore, a series of phased steps was formulated to establish a succession of bases from which to launch bomber strikes.

After much debate over the purpose, control and assignment of B-29s to the Pacific theater, the Joint Chiefs of Staff (JCS) agreed to a plan for the strategic bombardment of selected targets in Japan under unified command.<sup>46</sup> On 12 April 1944, the JCS authorized the creation of the Twentieth Air Force, with Gen Henry H. "Hap" Arnold as its first commander, reporting to the JCS in Washington. Two bomber commands, the XXth Bomber Command and the XXIst, were created within the 20th AF. The XXth Bomber Command, headed by Maj Gen Curtis E. LeMay, was stationed in the China/India theater, and the XXIst, headed by brig Gen Haywood S. Hansell, Jr., in the Marianas. The operating locations of the commands in the Pacific at the end of the war are shown in Figure 2.5.

### *Mission Planning, Targeting, and Operations*

Much of the mission planning for the Pacific campaign was based on the lessons learned from the bombing offensives in the European theater. Until a fighter escort base could be established on Iwo Jima, the bombers would have to undertake their missions alone. The limited range of the B-29 was a key critical

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<sup>45</sup>The treatment provided here of the bombing doctrine change is admittedly brief. For a more extensive discussion and contrasting perspectives, see Ronald Schaffer, *Wings of Judgment: American Bombing in World War II*, New York: Oxford University Press, 1985, pp. 103–106; and Michael S. Sherry, *The Rise of American Air Power: The Creation of Armageddon*, New Haven, CT, Yale University Press, 1987, Chapters 6 and 9.

<sup>46</sup>While the strategic air forces of both the United States and Britain were placed under joint U.S.–U.K. control for the Combined Bomber Offensive, the Pacific air campaign was primarily an American operation and, therefore, not subject to combined command.



factor for mission planning and necessitated the establishment of a succession of beachheads in the Pacific from which to conduct raids on Japan. The B-29 range when combined with the geographical constraints imposed limitations on the ability of XXIst Bomber Command to reach home island targets; these were left primarily to XXIst Bomber Command. Range was not only directly affected by inadequate maintenance and equipment malfunctions, it also constrained the bomber attack routes, thus giving some tactical warning to Japanese defenses.<sup>47</sup>

Because of the unfamiliarity with the airplane, assumptions about the survivability of the B-29 were uncertain at best and pessimistic at worst. Tests over the Gulf of Mexico were conducted as close to combat conditions as possible, including defensive formation flying, climb to 30,000 feet for the bomb run, and then return to base in loose formation. While the aircraft proved the feasibility of the mission, concerns remained about fuel consumption and daylight tactics.<sup>48</sup> Nevertheless, the aircraft was seen as crucial to the planned invasion of Japan.

***Industrial and Urban Targeting.*** In early 1944, the B-29s of XXth Bomber Command were organized into a seven-aircraft squadron, with four squadrons to each group and four groups per wing. Each plane had two eleven-man crews. Thus, a B-29 wing would have 112 aircraft and 2,464 crewmen.<sup>49</sup> The lack of success in XXth Bomber Command's early raids against targets in Bangkok and Yawata,<sup>50</sup> however, resulted in a change in command<sup>51</sup> and a reorganization similar to that employed by the Eighth Air Force in Europe. Twelve-aircraft combat boxes were set up in place of four-aircraft diamonds, night bombing was dropped in favor of daylight precision attacks, lead crews were designated, and a training school for bombardiers was established. Finally, new groups of three squadrons each, with ten aircraft per squadron, replaced the old structure. These measures improved the performance of the Command significantly.

The XXIst Bomber Command under the leadership of Brig Gen Haywood S. Hansell, Jr., was stationed in the Marianas. The Command's first mission was

<sup>47</sup>Hansell, 1980, p. 44.

<sup>48</sup>Hansell, 1986, pp. 165-166.

<sup>49</sup>David A. Anderton, *History of the U.S. Air Force*, Military Press, New York, 1981, p. 122.

<sup>50</sup>On 5 June, 1944, railroad shops in Bangkok were targeted by 98 B-29s, but weather and inability to assemble in formation resulted in 14 aborts at the start, and although 77 bombers dropped their bombs at altitudes from 17,000 to 27,000 feet, only 17 bombs fell in the target area. Five aircraft were lost returning to Chengtu, while 12 landed at bases other than their own, and 30 at bases not under the same command. The second attack, against Yawata on 15 June 1944, included 68 B-29s, of which only 15 used visual bombing of the target and 32 used radar; the rest aborted the mission. One B-29 was lost in combat, 6 for noncombat reasons, and 55 crewmen were killed in action (KIA) or missing in action (MIA). Only a single bomb hit a powerhouse almost one mile from the intended target. Anderton, pp. 122-123.

<sup>51</sup>Gen Arnold appointed Gen Curtis LeMay to take over command of the XXth Bomber Command (BC) on 29 August 1944.

against aircraft and engine factories in Toyko and Nagoya, almost 6,000 miles from the home base. It was to involve formation flying, no escorts, and precision targeting in daylight. Despite the skepticism over the ability of the B-29 to undertake such a mission, as well as the lack of crew experience with the aircraft, Hansell gave the go-ahead for the mission. Code named San Antonio, the strikes were directed against the primary target of the Musashino Aircraft Plant of the Nakajima Aircraft Company just outside Tokyo and secondary targets of the docking facilities and urban areas. San Antonio I took place on 24 November 1944. Of the 111 bombers that took off, 17 turned back because of fuel problems, 6 did not drop their bombs because of mechanical problems, 24 hit the aircraft plant, and 64 bombed the docks. Two B-29s were destroyed (one by combat) and eight were damaged. In addition, 277.5 tons of bombs were dropped.<sup>52</sup> This mission was affected by a fast jet stream, a phenomenon not previously encountered, that threw off bombing accuracy.

San Antonio II scheduled for three days later was to have targeted the same sites, but the weather forced the bombers to hit secondary locations. In both cases, the bombers faced a 12 to 14 hour mission under hazardous conditions, with no margin for error on returning to base. Additionally, the B-29s were forced to carry weight, primarily fuel, that far exceeded their design specifications.<sup>53</sup> Since bombing accuracy in the San Antonio operations was not very good, extensive crew training was initiated, and radar bombing equipment was improved.

In contrast to the XXIst Bomber Command, during its entire ten-month residence in India and China, the XXth Bomber Command dispatched only 49 missions and averaged two combat sorties per aircraft per month.<sup>54</sup> Because of this ineffectiveness, the aircraft of the XXth Bomber Command were moved to the Marianas in mid-January 1945.

Following the San Antonio raids, the JCS issued a schedule of missions against aircraft and engine factories in Tokyo, Nagoya, and Akashi in December 1944 and January 1945. In contrast to the bombing of Germany, the U.S. aircraft were met with relatively little resistance and, consequently, had few losses. Other raids conducted throughout the spring and early summer of 1945 were directed against oil refineries.

From early April to early May, the XXth Bomber Command provided tactical support to the invasion of Okinawa, specifically to raids on the airfields at Kyushu to suppress kamikaze operations.

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<sup>52</sup>Hansell, 1980, p. 39.

<sup>53</sup>Hansell, 1980, pp. 39-40.

<sup>54</sup>Anderton, p. 124.

Beginning in May 1945, incendiary attacks against Japanese cities were begun. Precision bombing during daylight had proven difficult because of weather conditions in the Pacific theater: the jet stream in addition to frequent heavy cloud cover over the targets made bombing accuracy difficult to achieve. The B-29's engines also did not perform as expected at the high altitudes required for precision bombing, and smaller bomb loads were necessary because of the distances involved. Finally, both fighter interception and flak were heavy. In contrast, incendiary attacks did not require precision bombing or formation flying; also they were not dependent on the weather or daylight. Given the few night-capable Japanese fighters and antiaircraft artillery (AAA), low level attacks (at 5,000 to 8,000 feet) could be conducted with much less operational impact on aircraft engines and fuel consumption.<sup>55</sup>

From a strategic perspective, Japanese society and war-supporting industry were more susceptible to the effects from incendiary attacks than the Germans. Also it was thought that such attacks would greatly weaken the will of the Japanese people and the leadership to continue the war.<sup>56</sup> The American leadership also may have been feeling pressured by the impending planned invasion of the Japanese home islands. In any event, the different strategy and operations resulted in widespread destruction of urban centers vital to the war economy of Japan. Seventeen operations were conducted that involved 6,960 B-29 sorties and 41,592 tons of bombs. Losses were 136 B-29s (about 2 percent of the sorties).<sup>57</sup>

*Countershipping.* Throughout the war, bombers were used to aerially mine rivers and harbors in support of specific military operations in the theaters of Southeast Asia, the Philippines, the Central Pacific, and later in Japanese home waters. At first the effort was believed to be a diversion from the Air Force's primary mission, but it turned out to be a major contribution to the defeat of Japan. One advantage to aerial mining was that unlike precision bombing it was not dependent on weather and could be performed at night regardless of cloud cover.<sup>58</sup>

The XXth Bomber Command conducted aerial mining, sea sweeps, and bombing operations against targets in China, including Hainan, Shanghai, and the Yangtze River. However, XXth Bomber Command operations were inherently limited because of the logistical problems associated with flying over the Burma

<sup>55</sup>Anderton, pp. 124-125.

<sup>56</sup>MacIsaac, David, ed., *The United States Strategic Bombing Survey*, Vol. VIII, "The Effects of Strategic Bombing on Japan's War Economy (Pacific Report No. 53)," Garland Publishing, Inc., New York, 1976, p. 37 (hereafter cited as USSBS, Vol. VIII).

<sup>57</sup>Hansell, 1986, pp. 231-233.

<sup>58</sup>Hansell, 1980, pp. 42-43.

"Hump." Other operations were conducted against the Ryukyus, the Korean Straits, and the Yellow Sea.<sup>59</sup>

With respect to countershipping in Japanese home waters, more than 12,000 mines were laid on 20 target areas, which effectively shut down Japanese shipping by sinking or damaging at least 700,000 and as much as 1,250,000 tons.

In general, operational bomber problems that resulted in technology adaptations included gunnery equipment, stationkeeping by radar (for formation assembly and maintenance in heavy weather), and search and rescue after ditching (the use of a transponder for locating downed crews).<sup>60</sup>

### ***Bombing Results***<sup>61</sup>

Totals for the entire air campaign conducted by XXth Air Force BC are shown in Table 2.6.

Following the San Antonio missions, training was initiated to improve visual bombing and radar-assisted bombing techniques. The latter employed the AN/APQ-13 radar equipment interconnected with the Norden bombsight. IPs were chosen that provided good radar returns. In conjunction with radar maps and precise determination of target locations, radar-assisted bombing came much closer to being as accurate as visual bombing. As with the bomber operations over Europe, however, accuracy was dependent on the skill of the bombardier.

Figures 2.6 through 2.8 illustrate the effect of the bombing (particularly the attack on 19 January 1945) on aircraft engine and airframe production at the Akashi Plant, Kawasaki Company.

**Table 2.6**  
**XXth Air Force Strategic Bombing Campaign Against Japan**

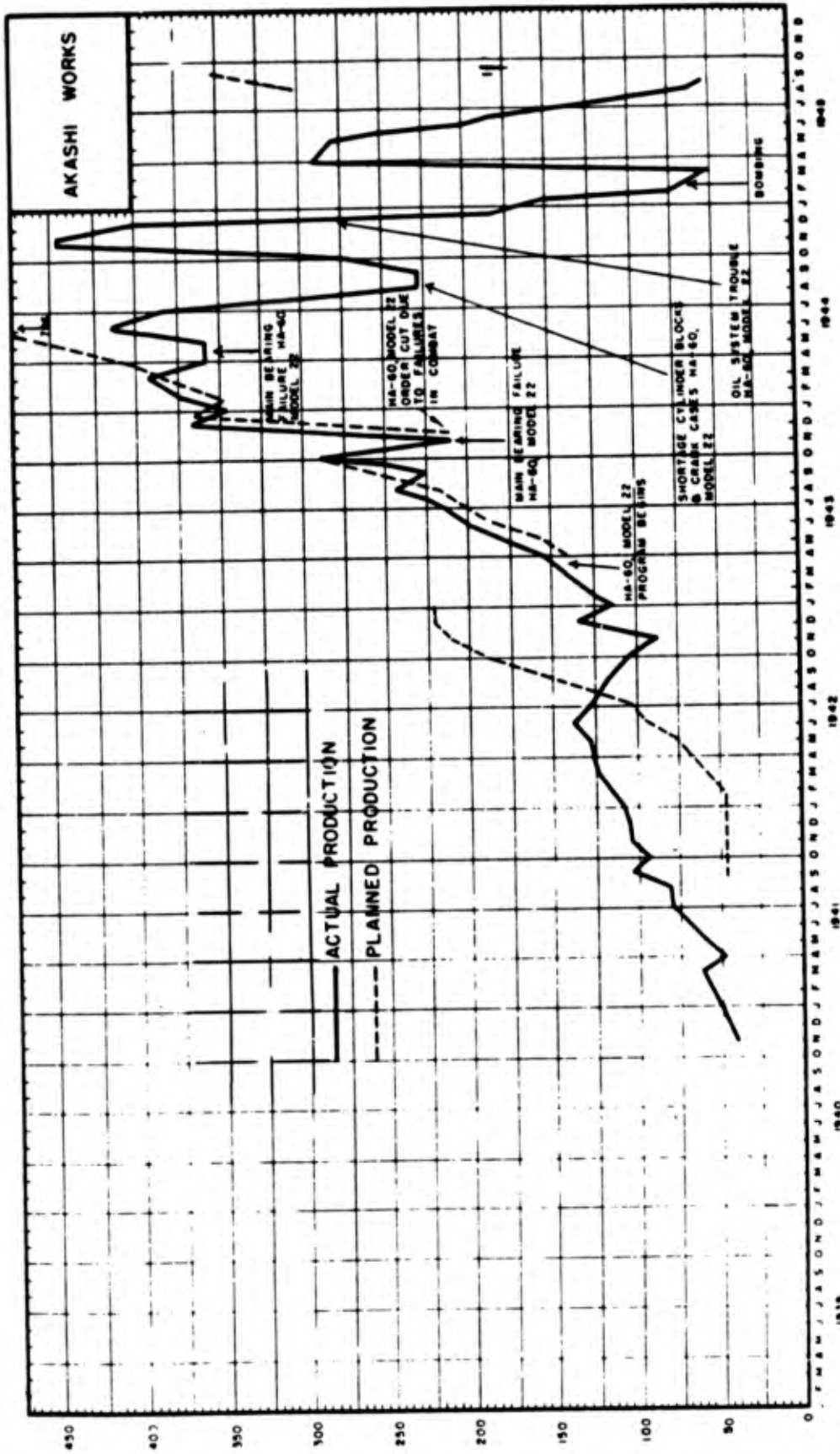
Precision Bombing Attacks	Sorties	Tons of Bombs
Aircraft and engine factories	2,838	14,152
Petroleum targets	1,437	10,600
Assorted industrial targets	1,459	8,093
Urban industrial area attacks	21,671	138,215
Aerial mining	1,750	
Total	29,155	171,060

SOURCE: Hansell, 1986, p. 234.

<sup>59</sup>USSBS, p. 36.

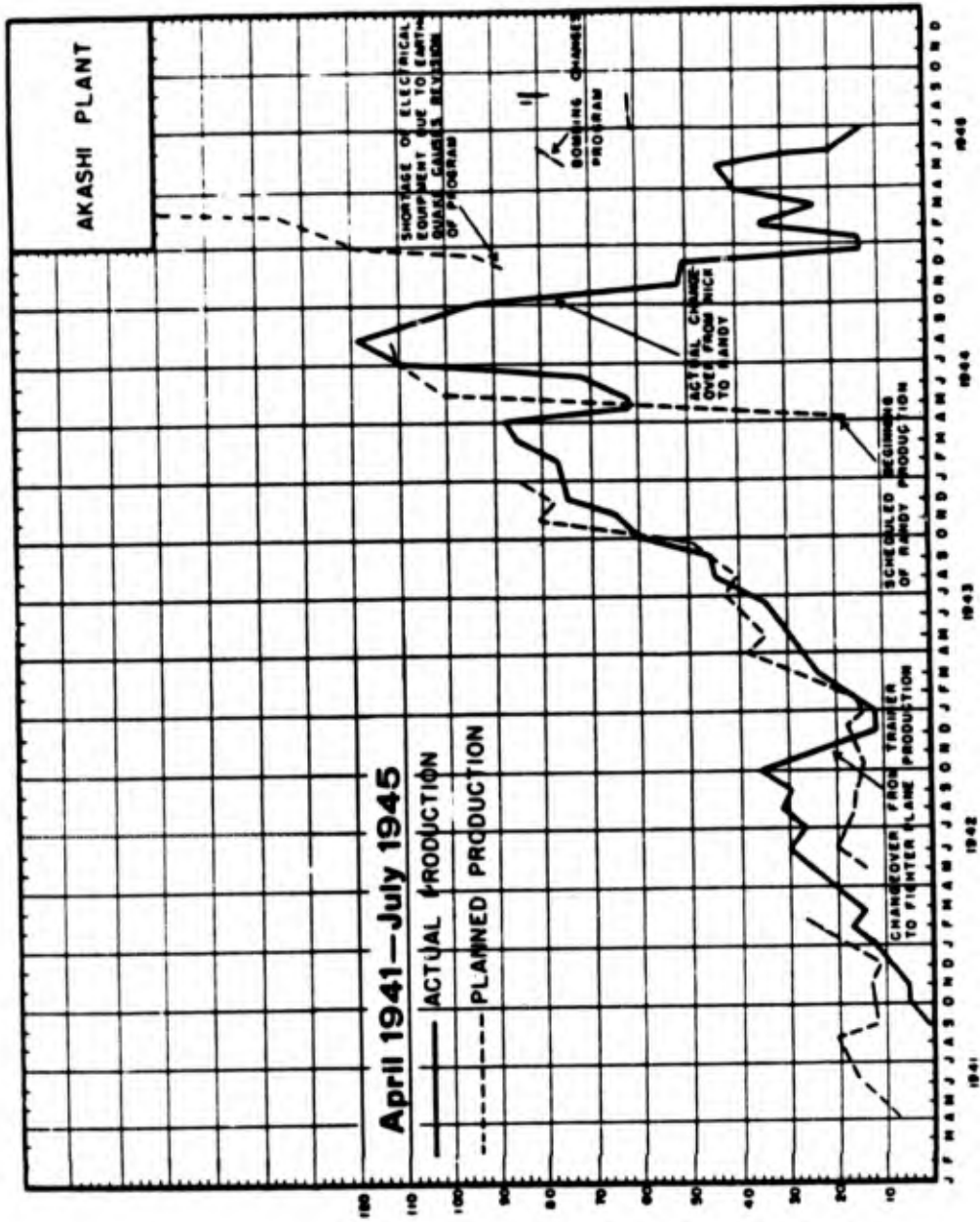
<sup>60</sup>Hansell, 1980, pp. 43-44.

<sup>61</sup>Most of the following discussion is taken from the *United States Strategic Bombing Survey*.



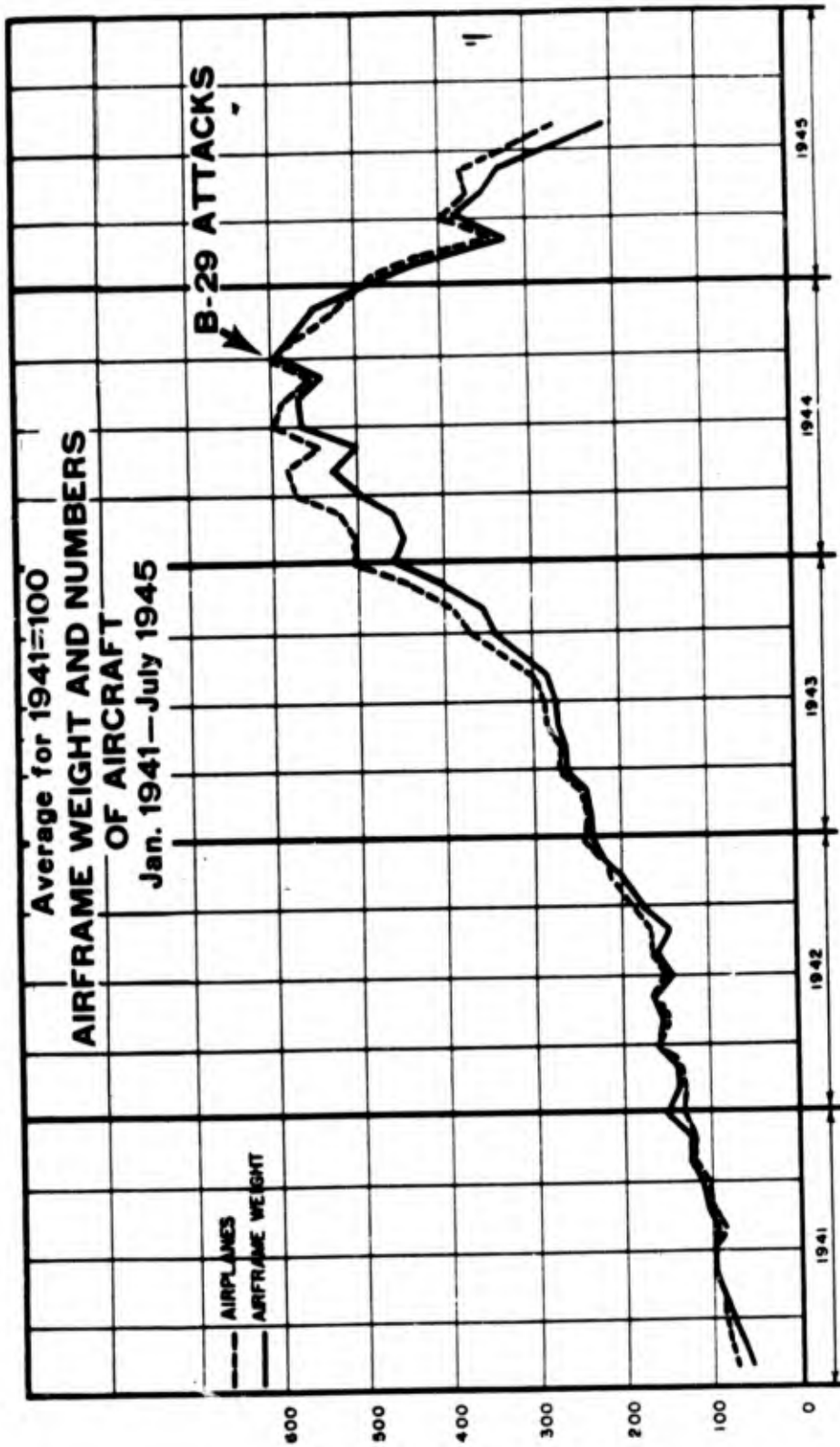
SOURCE: USSBS, reprinted in Hansell, (1980), p. 56

Figure 2.6—Engine Production, Akashi Plant, Kawasaki Company



SOURCE: USSBS, reprinted in Hansell, (1980), p. 57

Figure 2.7—Airframe Production, Akashi Plant, Kawasaki Company



SOURCE: USSBS, reprinted in Hansell, (1980), p. 59

Figure 2.8—Monthly Indexes of Aircraft Production

### *Effects on the Prosecution of the War*

As the United States Strategic Bombing Survey (USSBS) found after the war ended, the Japanese war economy was critically dependent on maritime shipping. Air power supported the naval blockade, which ultimately had the effect of completely shutting down Japanese access to its main shipping lines. Aerial mining of the Shimonseki Straits and inland Japanese seaports reduced traffic to 12 percent of the peak level by July 1945. U.S. aircraft were responsible for sinking 2,722 tons, or 33.6 percent of the total for the war (mines sank 513 tons or 6.3 percent; submarines sank 4,861 tons or 60.1 percent of the total). The Japanese steel industry, dependent on pig iron, ingot, and rolled steel supplies from Manchuria, was somewhat affected by the attacks on Showa Steel at Anshan by the XXth Bomber Command. In total, however, the USSBS noted that steel production was not severely hampered. When production dropped toward the end of the war, the cause was the lack of raw materials rather than the bombing campaign.

Oil supplies also were not affected directly by the bombing campaign—by that time, they were already severely limited and the USSBS stated that the bombing campaign was “almost superfluous.”

Curtailing the availability of aluminum and bauxite meant the ultimate end of aircraft production. Although production could have continued at low levels until June 1945, the strategic bombing campaign eliminated this possibility. The USSBS noted that

production during [November 1944 and the next 3 months] nosedived (engines 55 percent, from 3819 to 1695 per month, airframes 37 percent, from 2220 to 1391). Frantic measures to disperse the industry, undertaken immediately and continued to the end of the war, contributed even more heavily to the loss of output than did the direct effects of bombardment. From March 1945 on, incendiary area attacks were added to direct attack on plants in maintaining pressure against the industry, particularly in the case of components manufacture. . . . <sup>62</sup>

The USSBS also suggested that, had there been a different strategic objective in mind, such as using bombing to increase pressure on the Japanese leadership and population, rather than as a precursor to an invasion, targeting the railroads might have been decisive in ending the war sooner. Destroying the railroads would have hastened the disintegration of the social structure, presented the specter of possible starvation to the population, and severely affected Japanese military capabilities. It is worthwhile to include the USSBS’s reasoning for this line of argument:

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<sup>62</sup>USSBS, Vol. VIII, p. 50.

The purpose of the strategic bombing campaign was, until the last weeks of the war, the reduction of the armed strength with which the enemy could be expected to oppose a landing by our ground troops in November 1945. . . . The evidence suggests that definition of the air mission in these limited terms somewhat delayed the termination of the war. The larger mission of achieving a decision without invasion does not appear to have been recognized as the major objective until almost the end of the conflict and then only by part of the air forces engaged. Urban fire raids had, of course, begun on a large scale as early as March, but these appear to have been initially undertaken largely for operational reasons, as an easier way, than precision bombing, of getting at war production and of preventing its recuperation from precision attack. It was not until incendiary attacks were scheduled against urban areas of minor industrial importance, advance announcements of urban area raids made to the enemy and the atom bombs were dropped, that the primary mission of securing an independent decision was explicitly accepted for the B-29's. . . .

Although a decision was in fact obtained without invasion in the Japanese war, perhaps partly because United States forces were ready to invade in the immediate future, adherence to the limited concept of the role of strategic power caused a scattering and division of effort which probably delayed this result. . . .<sup>63</sup>

## **Strategic Bombardment and Air Interdiction: Bomber Operations in Korea**

### ***Background***

Although the end of World War II and the onset of the Korean War were separated by less than five years, the U.S. military forces had been downsized dramatically during that period. Also, an independent Air Force had been established. Air power doctrine had been reoriented from conventional strategic bombing to nuclear arms, with the expectation that the atomic bomb could remedy the conventional bombing problems encountered in World War II.<sup>64</sup> East-West tensions were escalating, but every potential military encounter carried the possibility of nuclear confrontation. Contributing to the milieu were contradictory statements among elements of the Truman Administration regarding the threat posed by Soviet clients China and North Korea to American interests in the Far East. Thus the stage was set for the North Korean invasion of the Republic of Korea (ROK) on 25 June 1950.

Misreading by the U.S. leadership of the state of preparedness by the ROK armed forces led to an underestimation of the forces needed to defeat the invasion. At

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<sup>63</sup>USSBS, Vol. VIII, p. 63.

<sup>64</sup>Kevin N. Lewis, *Strategic Bombing and the Thermonuclear Breakthrough: An Example of Disconnected Defense Planning*, RAND, P-6609, Santa Monica, CA, April 1981, p. 5.

first it was believed that only U.S. air and sea power were needed to bolster the South Koreans. Coupled with other political and diplomatic factors, however, the extent of the rout of the ROK forces in the face of a determined North Korean military force resulted in the commitment of U.S. troops to defend South Korea.<sup>65</sup> The contribution of the Far Eastern Air Forces' (FEAF) Bomber Command to the United States/United Nations response was in strategic bombing and air interdiction; it is the focus of this subsection.

Briefly, bombers carried out a short strategic campaign against North Korea with the objective of destroying North Korean war-supporting industrial and logistical systems. The campaign, begun on 8 August 1950, was characterized as "leisurely," largely because by that time the Allies had achieved air superiority.<sup>66</sup> It ended on 26 September after almost all the strategic targets had been destroyed.<sup>67</sup> As for air interdiction, B-29s were used against airfields along the Yalu, against interdiction targets such as railroads and industrial facilities, and occasionally for close air support.<sup>68</sup> Bombers also were employed in the interdiction of enemy logistical lines during the retreat to Pusan.

One month before the North Korean invasion, FEAF's inventory consisted of 1,172 aircraft, of which only 553 were resident in operational units. These 553 aircraft included 26 B-26 light bombers and 22 B-29 medium bombers as well as converted B-29s used for reconnaissance, weather, and other purposes.<sup>69</sup>

The mission of FEAF was air defense of Japan, Okinawa, and the Philippine Islands. While on paper the command had the largest number of Air Force units outside the continental United States, the budget cuts imposed by the Truman Administration had taken their toll on FEAF's operational capabilities. While aircraft could fly the first few days of the crisis, engineering and construction support were woefully unprepared and nowhere near World War II standards of readiness. These and other factors were to affect FEAF's ability to support the Eighth Army troops until additional support arrived from CONUS. FEAF's commander, General George E. Stratemeyer, made numerous requests for additional support to the USAF Chief of Staff, General Hoyt S. Vandenberg, but as General Vandenberg said later, the USAF was in reality "a shoestring Air

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<sup>65</sup>An excellent study of the Korean war and the events leading to it is Clay Blair's *The Forgotten War: America in Korea 1950-1953*, Anchor Books, Doubleday, New York, 1987.

<sup>66</sup>Anderton, p. 143.

<sup>67</sup>As Futrell recorded (p. 207), apparently the lack of strategic targets led to one 92d crew reportedly chasing an enemy soldier on a motorcycle down a road, dropping bombs until one hit the poor fellow.

<sup>68</sup>Momyer, p. 56.

<sup>69</sup>Other FEAF aircraft included 365 F-80s, 32 F-82s, 25 RF-80s, 26 C-54s, 23 SB-17s, and 4 SB-29s. Robert F. Futrell, *The United States Air Force in Korea 1950-1953*, rev. ed, Office of Air Force History, United States Air Force, Washington, D.C., 1983, p. 58.

Force"<sup>70</sup> and could not provide the level of support requested by General Stratemeyer.

Two bombardment groups (the 22d and 92d Bombardment Groups (Medium)) comprised of B-29s were relocated to the theater from CONUS. Additional reconnaissance, communications, and other support and reserve units also were deployed. Together with two other units, FEAF's 19th Bombardment Group (BG) and the 31st Strategic Reconnaissance Squadron, they became the FEAF Bomber Command (Provisional) on 8 July 1950 under the command of Maj Gen Emmett O'Donnell, Jr. The tasks of the Bomber Command were to interdict enemy lines of communication (LOCs) from the Han River to the Manchurian border and to destroy the facilities of war-supporting industries in North Korea.<sup>71</sup> In late July, the JCS authorized the deployment of the Strategic Air Command's (SAC) Fifteenth Air Force's 98th Bombardment Group (Medium) and the Second Air Force's 307th Bombardment Group (Medium), provided they conducted strategic bombing of North Korean targets.<sup>72</sup> These and other light bomber forces contributed to the achievement of air superiority early in the war by attacking North Korean airfields and marshalling yards. The ease with which air supremacy was attained in Korea before the Chinese invasion later proved to be an unrealistic expectation on the part of USAF planners when faced with similar circumstances in Vietnam.

### *Mission Planning, Targeting, and Coordination*

The Strategic Air Command was responsible for determining target priorities and force requirements based on an assessment of North Korean industrial development. An identification of war-supporting industry and military targets showed that they were located principally in five areas: Wonsan, Pyongyang, Hungnam (Konan), Chongjim (Seishin), and Rashin (Najin). All except Pyongyang were located on the northeastern coast of Korea. Several were major ports with petroleum refineries, railroad yards, iron works, and chemical factories. Because of their close proximity, SAC recommended a targeting emphasis on area rather than precision attacks, and the use of incendiary bombs rather than demolition bombs. This strategy would ease the crews' problems with daylight attacks and weather conditions, and if everything went well, two medium-bomber groups could destroy the five areas in thirty days. The SAC

<sup>70</sup>Quoted in Futrell, p. 69. Air Force strength as of 30 June 1950 was 411,277 officers and men, less than 18 percent of the peak wartime strength of 2,411,294; it possessed less than 2500 jet aircraft of all types.

<sup>71</sup>Futrell, p. 47.

<sup>72</sup>Futrell, pp. 71-72.

leadership as well as the JCS viewed this emphasis favorably,<sup>73</sup> but General Douglas MacArthur insisted that the bombers conduct interdiction and other missions in support of the Eighth Army. With the bribe of an additional two medium-bomber groups, General MacArthur agreed to initiate attacks on strategic targets. However, concerned over potential Communist propaganda that might surface as a result of possible civilian deaths, Washington stepped in and halted the use of incendiary munitions.<sup>74</sup> This ban on incendiaries led to a requirement for additional sorties per target.

After the early missions against Wonsan, strategic bombing attacks were carried out against the chemical factory at Hungnam in late July 1950. Operational procedures established for this mission led to routine operational planning in subsequent strikes against the other strategic targets (see discussion below). With the end of the strategic bombing campaign on 26 September 1950, the JCS directed that United Nations air forces would be employed only against North Korean targets having tactical significance.<sup>75</sup>

Both geography and weather were critical factors in mission planning, targeting, and coordination. Korea's mountainous terrain made air interdiction and close air operations in support of ground operations difficult. The Japanese occupation of Korea had resulted in the construction of ten military airfields—most of which the South Koreans did not use or maintain—and the development of an extensive railroad system. Furthermore, maps and charts were based on the Japanese Imperial Land Survey and were fairly accurate, as were aerial maps of South Korea. Aerial maps of North Korea, however, were not generally available, and those that were tended to be inaccurate, with errors of anywhere from 500 to 1000 feet common. Transliteration of place names often was inconsistent as well. The bad weather of the monsoon season compounded the problems caused by terrain and made the weather prediction necessary for mission planning difficult at best.<sup>76</sup>

Two problems in mission planning and resource allocation surfaced early in the air campaign that were to provide precedents for Vietnam and the Gulf war. The first was the operational control and coordination of airspace among the air units

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<sup>73</sup>A veteran of the strategic bombing campaign against Japan, Maj Gen Emmett ("Rosie") O'Donnell, Jr. was in favor of using incendiary munitions and said, "It was my intention and hope . . . that we would be able to get out there and to cash in on our psychological advantage in having gotten into the theater and into the war so fast by putting a very severe blow on the North Koreans, with an advance warning, perhaps, telling them that they had gone too far in what we all recognized as being an act of aggression . . . and [then] go to work burning five major cities in North Korea to the ground, and to destroy completely every one of about 18 major targets." Quoted in Futrell, pp. 185–186.

<sup>74</sup>Incendiaries eventually were authorized for use on North Korean cities and were employed first against Chongjin on 4 November 1950. Futrell, pp. 221–222.

<sup>75</sup>Futrell, p. 194.

<sup>76</sup>Futrell, pp. 62–66.

of the different services. While the Air Force advocated the concept of a single manager for air, the other services worried that their air assets would be placed under the control of the USAF to the detriment of supporting Navy and Marine operations. The concepts of route packages and coordination control eventually were agreed on and provided the context for air support for ground and strategic operations.<sup>77</sup>

The second problem concerned the role in and authority for targeting that General MacArthur's General Headquarters (GHQ) Target Group insisted on retaining. That authority encompassed the designation of medium-bomber targets and the establishment of target areas and attack priorities. The staff of the GHQ Target Group were not familiar with bomber operations (for the most part they were Army officers); also they did not provide consistent and accurate target lists. One Air Force observer noted that the targets identified by the GHQ Target Group were too close to the battle zone, too many to be attacked by available B-29s, and too vague to be spotted by bombardiers, even under good conditions. Consequently, attacks designated by the GHQ Target Group that utilized bombers against battlefield interdiction targets were perceived to be a misapplication of air power. A Far East Command (FEC) Target Selection Committee was established to develop air campaigns against targets consistent with Commander in Chief, Far East (CINCFE) and Commander, FEAF objectives and became much more effective. The time delay, however, in setting up an effective targeting process was costly to events on the ground.<sup>78</sup>

Throughout the war no restrictions were placed on bombing activities except to avoid the borders of Manchuria and Soviet Siberia. From the beginning of the crisis, FEAF was authorized to attack North Korean "air bases, depots, tank farms, troop columns, and other purely military targets such as key bridges and highway or railway critical points."<sup>79</sup> Humanitarian concerns about collateral damage were levied on the bombing, however, largely because of memories of World War II bombing against cities.<sup>80</sup> Since officially U.S. forces operated under the umbrella of a United Nations force, the sensitivity of attacking certain targets meant a certain amount of coordination with other key capitals. This political reality imposed a time delay in attacking those targets.

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<sup>77</sup>See Winnefeld and Johnson, Chapter 5.

<sup>78</sup>Futrell, pp. 51-55.

<sup>79</sup>Futrell, p. 36; Momyer, pp. 171-172.

<sup>80</sup>Futrell, pp. 41-43.

## *Operations and Tactics*

**Strategic Bombing.** The slow pace of the strategic bombing campaign was dictated somewhat by the airspace congestion over the theater that was caused by the concurrent interdiction campaign. Strategic bombing missions of two groups each were conducted at a maximum level every third day; by 20 August, missions of three groups were conducted with two-day stand-downs in between each one for crew recuperation and aircraft repair and maintenance.<sup>81</sup>

Planning for the attack on Hungnam led to the formulation of certain operational procedures that became the bases for subsequent attacks. For example, the monsoon season dictated the use of radar bombing supported by whatever visual intelligence was available. In this case, the dependence of the Bomber Command's operations officers and aircrews on intelligence photographs was increased. Unfortunately, the photographs available to Bomber Command were of poor quality but, as luck would have it, some found archived on Guam were used to replace them.<sup>82</sup> Because of the weather, operations planners specified three methods of attack—squadrons in trail, bombing visually on squadron leaders; squadrons in trail, bombing by radar on squadron leaders; or a bomber stream of individual aircraft, bombing individually by radar. The airborne commander would decide which method to use once he determined local weather conditions at the target.<sup>83</sup>

The mission "Nannie Able" against the Chosen Nitrogen Explosives Factory took place on 30 July using 47 B-29s carrying 500-pound bombs and flying in V formations. The attack took four minutes. Cloud cover over the target resulted in the use of the AN/APQ-13 radar. Since the explosions cleared away some cloud cover, visual targeting and confirmation were accomplished. All bombs fell in the target area and destroyed 30 percent of the factory and heavily damaged 40 percent of it. "Nannie Baker," conducted on 1 August against the Chosen Nitrogen Fertilizer Factory, employed 46 aircraft with the same procedures except that clear weather allowed the use of the Norden bombsight. Finally, on 3 August "Nannie Charlie" hit the Bogun Chemical Plant, bombing through clouds at 16,000 feet. All missions were successful in knocking out the largest chemical and explosives centers in Asia.<sup>84</sup>

Airspace congestion at Yokota and Kadena necessitated the use of traffic control and ground-controlled approach (GCA) at these bases. The congestion also affected the bombing campaign by imposing a routine of staggering over the

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<sup>81</sup>Anderton, p. 143.

<sup>82</sup>Futrell, p. 188.

<sup>83</sup>Futrell, p. 188.

<sup>84</sup>Futrell, p. 190.

target to stagger the return home. It was fortunate that the North Korean air defenses were relatively weak, as the leisurely approach and less-than-concentrated effort could have been threatened severely had AAA or fighters been at strength.

Subsequent missions in the strategic bombing campaign resulted in an average of 8.9 sorties per month between 13 July and 31 October 1950, with 30,136 bombs dropped by Bomber Command.<sup>85</sup> The last strategic bombing mission occurred on 26 September as an attack on the Fusen Hydroelectric Plant near Hungnam. The entire campaign lasted about two months using only 2.5 percent of the B-29 effort but resulting in approximately 55 percent destruction on the North Korean industrial facilities.<sup>86</sup> Accuracy was extremely good, not only because of the lack of opposition but also because of the skillful crews; consequently, little collateral damage was suffered.

*Air Interdiction.* In November 1950 the use of B-29s against interdiction targets in North Korea, particularly bridges, was less effective than the strategic bombing campaign. The bombers were hampered by territorial overflight restrictions (on those targets on the Yalu River near the Manchurian border), by altitude requirements (18,000 feet to escape flak), by heavy crosswinds over the targets, and by the structural strength of the targets themselves (built by the Japanese to withstand natural conditions). The B-29s proved to be better at area rather than point targets. They were used during the Communist Chinese offensive to attack hostile supplies and personnel at Pyongyang and the international bridges over the Yalu in early 1951, with mixed results. At that time the air superiority battle was heating up, particularly in the area known as "MiG Alley," and the slow B-29s were faced with a strong threat from the Chinese MiGs. Extensive fighter support was needed to minimize bomber losses; however, several aircraft were lost and damaged, resulting in a halt to bombing certain targets until fighter support could be "beefed up."<sup>87</sup>

The spring 1951 missions against the North Korean communications and logistics networks (called Operation Strangle, succeeded by Operation Saturate) were more successful, because of good weather and the lack of strong opposition. Many of the rail lines and communication lines were repaired almost as soon as they were attacked, and truck and rail convoys were moved at night; thus, the end result was that the bombing was not as effective as expected. Bombing attacks, therefore, were conducted at night by either "night intruders" (B-26s) or

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<sup>85</sup>Futrell, p. 191.

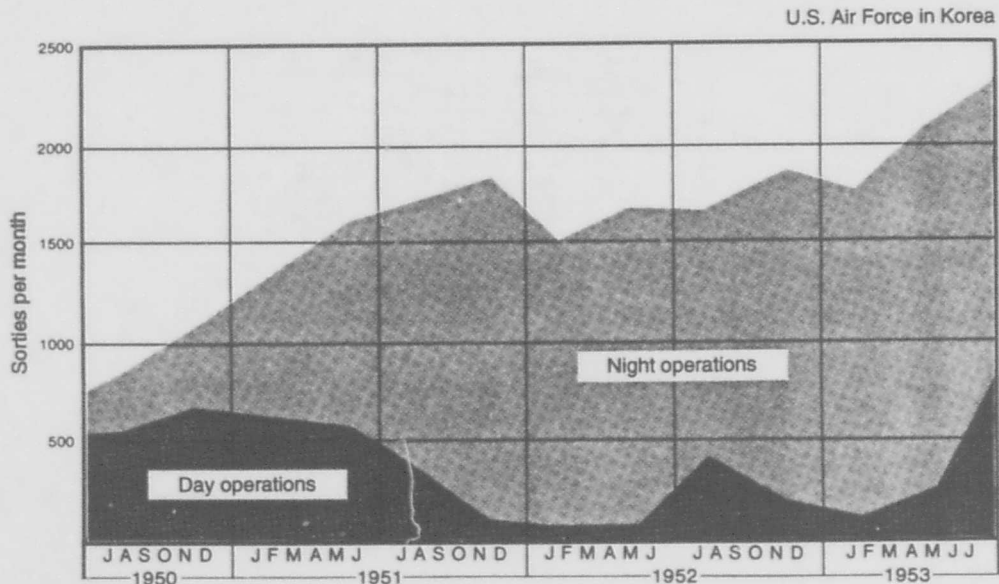
<sup>86</sup>Futrell, pp. 194-195.

<sup>87</sup>Futrell, pp. 296-300.

"lone wolves" (glass-nosed B-26Cs).<sup>88</sup> Figure 2.9 shows the distribution of the light bomber (B-26) effort between day and night operations.

In sum, the strategic bombing campaign and the interdiction effort were substantially different from each other:

... the FEAF Bomber Command was eventually responsible for interdicting 60 bridges, 39 marshaling yards, and 35 supply and communications centers—a substantial target list for three groups of medium bombers. In the autumn of 1950 bombing from 10,000 feet with no fear of enemy air opposition, each B-29 had usually dropped four bombs per run over bridge targets, and Bomber Command had computed that 13.3 runs were required to destroy an "average" bridge. Such bombing was not quite up to the standards of accuracy to be expected from Norden bombsights, but with five groups of bombers, Bomber Command had run through its bridge targets lists so rapidly that no one had bothered too much about the matter. In the early months of 1951, however, General Briggs had to expect the utmost of each bomber crew. Now, Bomber Command had a daily sortie capability of 24 B-29s. The 98th Bombardment Group usually furnished 24 sorties one day, and the 19th and 307th Groups furnished 12 sorties each on the following two days. And the bombing problem was much more complex. Because of Communist gun batteries, the medium bombers often had to attack bridge



SOURCE: Futrell, p. 454.

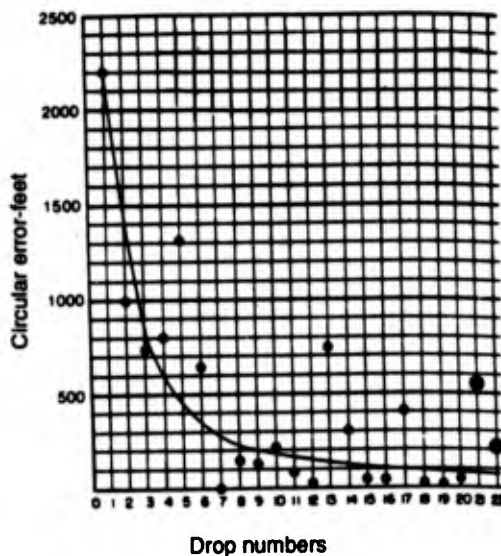
Figure 2.9—Distribution of Bomber Effort Between Day and Night Operations

<sup>88</sup>See Futrell, pp. 325–331, 453–461.

targets from 21,000 feet, and because of the MIG-15 fighters the bombers could seldom make more than a single run on a target.<sup>89</sup>

The approach developed in response was to attack bridges using three or four aircraft on an inside acute angle of 28 to 37 degrees and heavier bombs (1000–2000 pounds). Radio-controlled (“razon”) bombs of World War II vintage were employed.<sup>90</sup> In December 1950 the “tarzon” bomb was developed and employed. These bombs weighed 12,000 pounds and proved effective against bridge spans. Figure 2.10 shows tarzon accuracy. Subsequent missions, however, found that the missiles had technical problems and could not be salvoed “safe,” i.e., jettisoning the missile would make its tail assembly come off on impact and cause the missile to arm and explode. Eventually the program was discontinued (in August 1951), but its record consisted of 30 bombs dropped, 6 bridges destroyed, 1 damaged, 3 duds, and 19 targets missed.<sup>91</sup>

Just as in World War II, interdiction bombing technique involved the use of Pathfinder forces. In attacks over South Korea, however, PFF consisted of “Hunter-Killer” teams of B-26s using flares to mark targets along the enemy lines of communication. North Korea was considered too dangerous to use this



SOURCE: Futrell, p. 320.

Figure 2.10—Tarzon Accuracy

<sup>89</sup>Futrell, p. 318.

<sup>90</sup>Razon bombs of 1000 pounds had remotely controlled tail fins which responded to the bombardier's signaled guidance to the target with range and azimuth corrections.

<sup>91</sup>Futrell, pp. 322–323.

technique, so SHORAN<sup>92</sup> bombing was employed first with B-26s and later with B-29s.

### *Bomber Attrition and Losses*

Figures 2.11 through 2.14 illustrate the types and totals of sorties, ordnance tonnages, and operational losses for each service for Korea. (No breakout of bomber totals was available.) Only one bomber was lost to enemy action in the strategic bombing campaign. However, the same could not be said for the interdiction campaign later in the war. By mid-April 1951, Bomber Command had lost eight bombers and crews; excluding planes with combat damage, it only had 75 aircraft left. While command strength was brought back up to 99 aircraft, command leadership was told by the USAF chief of staff that the Air Force could not support more than 12 sorties a day. With this level of sorties, Bomber Command priorities became airfields and ground support.<sup>93</sup>

### *Bombing Results*

While the strategic bombing campaign was effective, the use of bombers in interdiction roles was decidedly mixed. The "night intruder" approach, while fairly effective in negating Communist truck convoys, was hampered by problems in getting bomb damage assessment information. Also, over time the interdiction program declined in effectiveness primarily because of enemy countermeasures. BDA never could determine the impact of the bombing on North Korean intentions, either as to the target's significance to the regime or to the willingness to end the war.

Both the air superiority campaign and the bombing of North Korean airfields had a decisive effect on the North's ability to perform air attacks against USAF airfields or United Nations troops. North Korean negotiators grudgingly acknowledged this effect at Kaesong in August 1951.<sup>94</sup>

### *Effects on the Prosecution of the War*

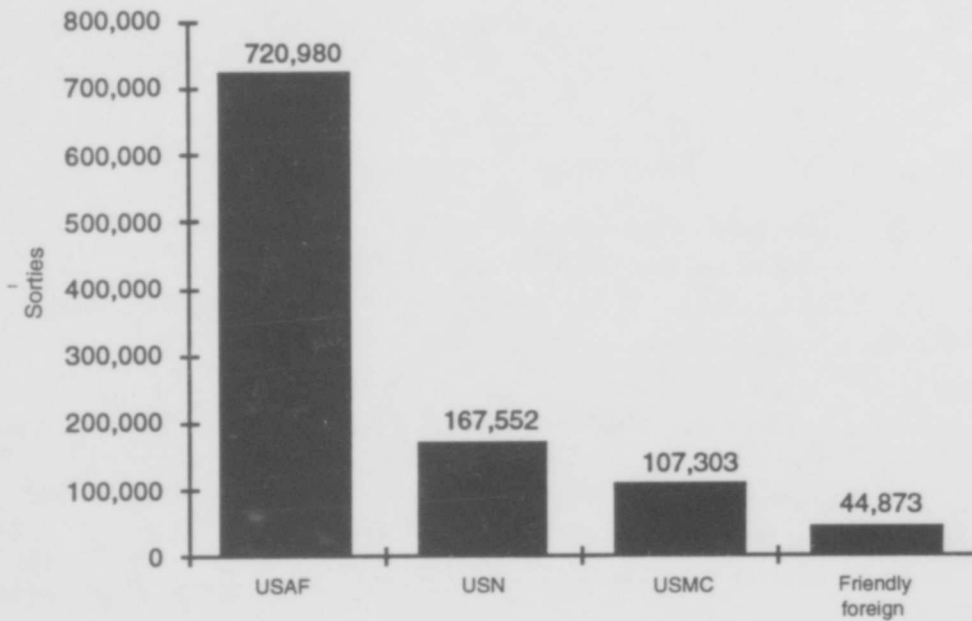
To summarize, the bulk of the Bomber Command efforts lay in air interdiction in support of ground operations. While the strategic bombing campaign against

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<sup>92</sup>SHORAN was a precise short-range electronic navigation system using the time of travel of pulse transmissions from two or more fixed stations to measure slant range distance from the stations. Momyer, p. 180.

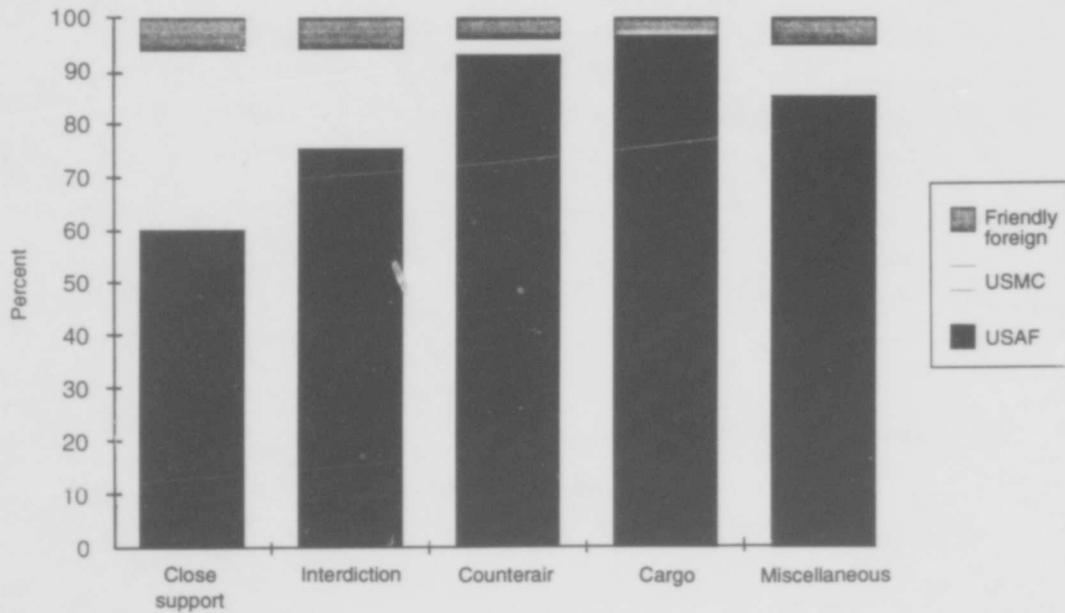
<sup>93</sup>Futrell, p. 322.

<sup>94</sup>Momyer, pp. 116-117.



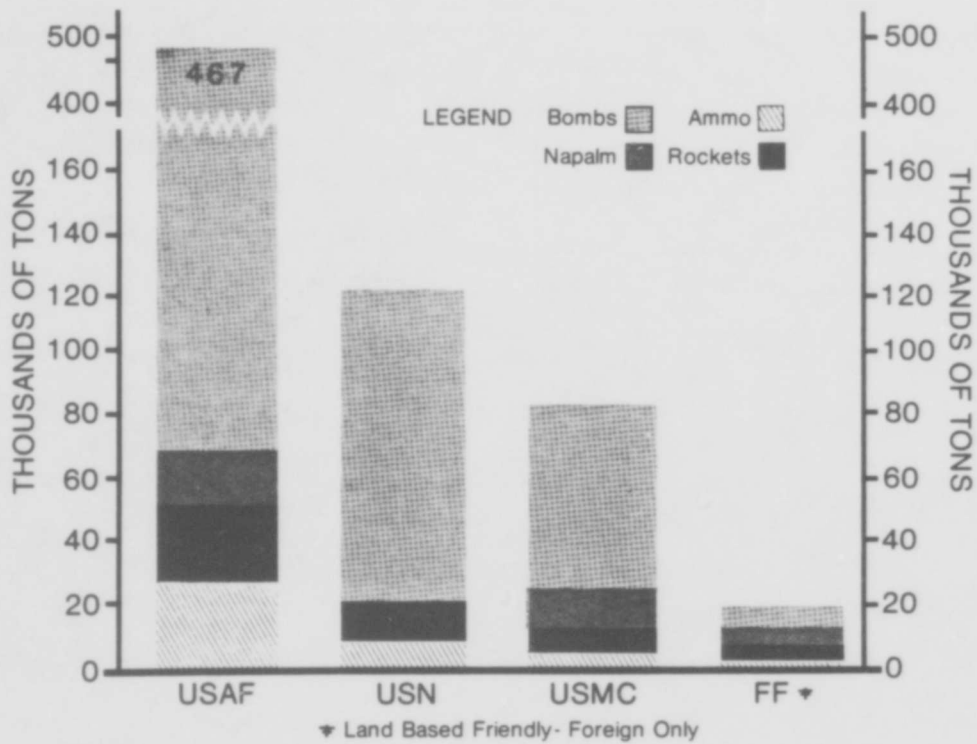
SOURCE: Futrell, p. 690.

Figure 2.11—Total Sorties



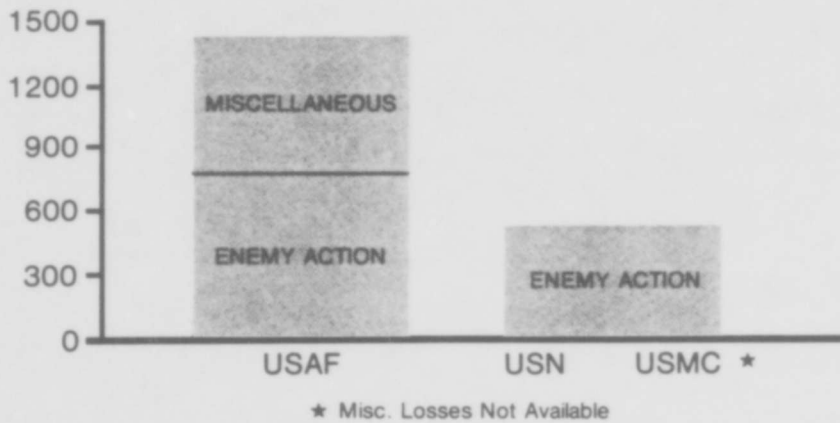
SOURCE: Futrell, p. 690.

Figure 2.12—Type of Sorties by Percent



SOURCE: Futrell, p. 691.

Figure 2.13—Ordnance Tonnages



SOURCE: Futrell, p. 691.

Figure 2.14—Operational Losses

North Korean industrial and communications targets was fairly successful, the interdiction effort was less so. Air power was critical in the early days of the retreat following the Chinese invasion, as well as in paving the way for ground offensive actions. Nevertheless, Bomber Command crews were not prepared to conduct the interdiction campaign, having prepared more for strategic bombing.

As we shall see in the next subsection, the lessons learned in World War II and in Korea had to be relearned in Vietnam, and, to a certain degree, in the Gulf War.

### **3. Realities Revisited: B-52 Operations in Vietnam and the Persian Gulf War**

Having observed long-range, heavy bomber operations in both World War II and Korea, we have seen the impact of both technology and tactics and the evolution of how the bomber was exploited to accomplish strategic and military objectives. But several fundamental truths remain. Despite the increase in precision and lethality, which enables the military planner to reduce the numbers of aircraft and men he or she has to send against a target, strategic bombing by heavy bombers has remained most effective against area rather than hard targets. Their vulnerabilities, as compared to fighters or even fighter-bombers, dictate a preference for high altitude attacks. Exploiting their capability to carry far more weapons per platform over great range, however, is what makes their use more attractive for area or carpet bombing. Furthermore, their value as psychological weapons cannot be discounted. These factors are considerations that must be part of operational planning for air campaigns.

This section focuses on the role of the B-52 in two more recent conflicts: Vietnam and Operation Desert Storm. We have chosen to focus on the B-52 rather than bombers in general because of the longevity of the "Buff" and to explore its roles in both wars, separated as they are by two decades or more. The first part of this section assesses the contribution of the B-52 in defending the Marine base at Khe Sanh and, a few years later, in supporting Linebacker II. The second part of the section addresses the role of the bomber in Desert Storm operations; by necessity, it is much briefer as information about current bomber operations is more restricted and unavailable in the open literature to the same extent as the previous campaigns. Consequently, our discussion presents highlights only.

#### **Background**

During the buildup of American forces from 1965 to 1968 and subsequently through to early 1973, the air war in Vietnam reflected the belief by the American civilian and military leadership in the criticality of air power to a successful outcome of the war. Disagreements over the extent and degree to which air power would be applied and in what manner, however, led directly to operational problems.

The Vietnam War differed notably from the other historical conflicts in which long range bombers were employed, largely because its nature was one of conventional, guerrilla warfare with many battles relatively small in scope in comparison to those of World War II. Like Korea, and except for the few major cities, the scene of conflict was primarily rural, rather than heavily industrialized. Consequently, the Air Force doctrine of strategic bombardment of an enemy's vital centers of power could not be applied as easily. Rather, the air campaign tended to focus on close air support to ground troops, interdiction of Viet Cong (VC) and North Vietnamese Army (NVA) supply lines, and general harassment of the enemy in his base areas. The strategic objectives of the air campaign were to bolster the South Vietnamese government and to pressure the North to withdraw its support of the Viet Cong. Along with other factors, pursuit of these objectives led to a *de facto* functional and geographical division of labor among the air elements of U.S. armed forces in Vietnam. The Navy conducted a carrier-based air campaign against North Vietnam and maritime anti-infiltration operations, while the Air Force provided air support to the U.S. and South Vietnamese armies and coordinated the air war among the services. Operationally responsible for I Corps, the Marines conducted an independent air arm within III Marine Amphibious Force (MAF) consistent with their doctrine until the Air Force became the "single manager" for air in 1968.<sup>1</sup>

Despite the continued press for centralized control of all air assets by Air Force commanders in Vietnam, command and control of B-52 operations typified the complexity, redundancy, and inefficiency evidenced by other aspects of control of air assets in the theater. Not only was SAC involved, but also the Commander, United States Military Assistance Command, Vietnam (COMUSMACV), the JCS, the 7th Air Force, the Commander in Chief, Pacific Command (CINCPAC), and Carrier Task Force 77 (CTF-77). Furthermore, SAC was unwilling to transfer operational control over its B-52s allocated to the theater in Vietnam. The B-52s were viewed as vital for strategic deterrence, and SAC was reluctant to adversely affect its capability to perform its strategic nuclear mission should that occasion arise. The "mindset" of employing heavy bombers for strategic bombardment-type missions also inhibited SAC's willingness to allow them to be used in tactical/conventional roles, such as air interdiction and close air support. Although the bombers proved to be

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<sup>1</sup>Shulimson, Jack and Maj. Edward F. Wells, USMC, "The Marine Experience in Vietnam, 1965-1971: First In, First Out," *Marine Corps Gazette*, January 1984, included in *The Marines in Vietnam 1954-1973: An Anthology and Annotated Bibliography* [hereafter cited as *Anthology*] 2nd ed., Washington, D.C.: History and Museums Division, Headquarters, U.S. Marine Corps, 1985, pp. 25-26. More extensive discussions of unity of command and control of joint air operations for Vietnam are contained in Winnefeld, James A., and Dana J. Johnson, *Joint Air Operations: Pursuit of Unity in Command and Control, 1942-1991*, Annapolis: Naval Institute Press, 1993.

extremely effective when used in the Arc Light<sup>2</sup> missions, their employment continued to be considered in terms of strategic, i.e., nuclear, deterrence long after Vietnam.<sup>3</sup>

Throughout most of the war, severe political constraints were placed on Arc Light strikes, especially for politically sensitive operations such as the secret bombing of Cambodia that required approval of target selections by Washington. This decisionmaking process took valuable time that had an adverse operational impact given the transitory nature of many of the targets. Furthermore, several other factors, including both a graduated escalation of the bombing and a “stop-and-go” bombing approach concurrent with diplomatic negotiations, also constrained the effective employment of the B-52s.

B-52s were used to support many ground operations in South Vietnam in the early years of U.S. involvement. B-52s were first used against North Vietnam in April 1966 when the heavy bombers interdicted North Vietnamese lines of communication leading to the Demilitarized Zone (DMZ) and the Ho Chi Minh Trail in Laos. Only one campaign in South Vietnam, the defense of the Marine base at Khe Sanh, however, might be considered comparable to other “traditional” battles for which air power was considered to be ideally suited. In this instance, the B-52s were used in close air support and air interdiction roles rather than strategic bombardment. The other campaign of interest where B-52s were used in round-the-clock bombing of North Vietnam was Linebacker II, 18 to 29 December 1972. Hitting a range of targets around Hanoi, Linebacker II was a coordinated effort employing not only B-52s, but also A-7s, F-111s, and F-4s. Linebacker II was preceded by several other air operations, notably the Rolling Thunder and Linebacker I programs. These operations are detailed next.

### *Early Deployment of B-52s: The Arc Light Missions*

B-52s and their supporting KC-135 tankers were deployed from Strategic Air Command bases in CONUS for employment in Arc Light operations against targets in South Vietnam beginning on 18 June 1965. Figures 3.1 and 3.2 show the total Arc Light sorties and USAF bombers in Southeast Asia from 1965 until 1973. B-52s first were used to directly support ground troops in November 1965 during the defense of the Plei Me camp near Pleiku. More than 900 bombs were dropped on the enemy by the “Buffs.” Other notable “firsts” include the first

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<sup>2</sup>Arc Light was the name given to SAC B-52 strikes in South and North Vietnam and Laos.

<sup>3</sup>It also preceded Vietnam, as strategic bombardment was the key rationale for the effort to separate the Air Force from the Army during the 1920s to the 1940s.

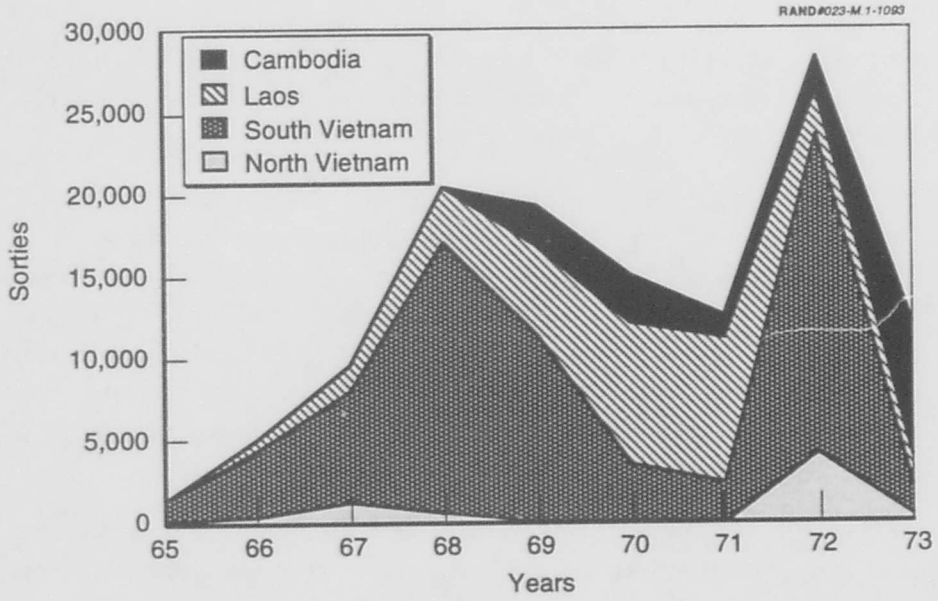


Figure 3.1—Arc Light Operations in Southeast Asia, 1965-1973

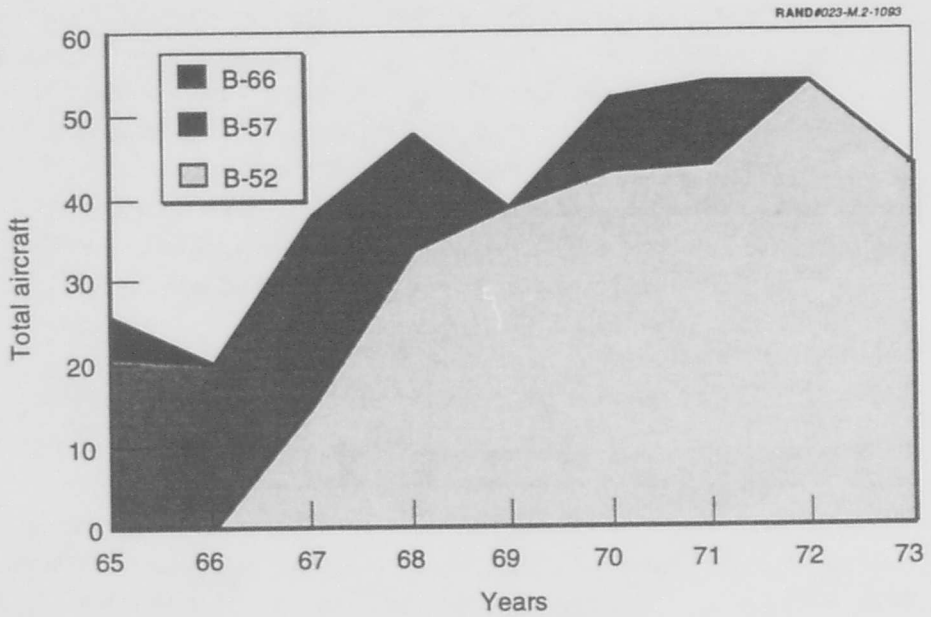


Figure 3.2—USAF Bombers in Southeast Asia, 1965-1973

B-52 raids into Laos in December 1965, and the first use of B-52s against targets in North Vietnam in April 1966.

Initially, Arc Light operations were hampered because (1) no radar film files were available for Southeast Asia for use in SAC bombing procedures, and (2) the terrain did not have any identifiable man-made features to provide adequate radar returns. An Army helicopter carrying a beacon crew was used to gather data for the first missions over South Vietnam. Given the vulnerability of the Army crew and helicopter, reconnaissance using a single B-52 was initiated at the earliest opportunity, but the helicopter approach continued to be used in the early Arc Light operations.

The political sensitivity of the first Arc Light mission in June 1965 led to last-minute meddling by the political leadership in Washington on two counts: (1) to move the operation up by 24 hours (i.e., to be launched only two hours after the phone call—the SAC Commander said it was too late to do that) and (2) to include a senior Air Force officer aloft for command and control purposes.<sup>4</sup>

As recounted by Schlight, the operation did not go as smoothly as hoped. In rendezvousing with KC-135 tankers over the Philippines, weather factors led to the collision of two Guam-based B-52 aircraft, with the loss of both planes and eight of twelve crew members. Another aircraft aborted for mechanical reasons. Out of an initial group of 30 aircraft, 27 planes arrived at their target area in South Vietnam. Controlled by the target beacon delivered by the helicopter the night before, they dropped their ordnance<sup>5</sup> at altitudes of 19,000 to 22,000 feet onto the 1-mile by 2-mile target box. Within 30 minutes 1300 bombs fell, slightly more than half in the target box. Thirteen hours later, the aircraft landed in Guam, being careful to avoid the Cambodian border along the way.<sup>6</sup> Ground reconnaissance teams subsequently noted that the Viet Cong had evacuated the area before the attack, and there was little evidence of damage to the site.

Despite the less than encouraging results, the early experiences with the heavy bombers encouraged COMUSMACV, General William Westmoreland, to request daily B-52 strikes. With JCS approval, he worked directly with the headquarters for the bombers at 3d Air Division on Guam. JCS constraints on operational control of the bombers, however, were levied on Westmoreland, "subject to

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<sup>4</sup>John Schlight, *The War in South Vietnam: The Years of the Offensive 1965–1968*, Office of Air Force History, United States Air Force, Washington, D.C., 1988, pp. 51–52.

<sup>5</sup>The ordnance consisted of 24 planes carrying 51 750-pound bombs each (27 inside the bomb bays and 24 externally); the remaining 6 aircraft carried 1000-pound armor-piercing bombs. Schlight, p. 52.

<sup>6</sup>Schlight, p. 52.

monitoring and possible veto by higher authority."<sup>7</sup> JCS concerns stemmed from the proximity of the bomber operations to the Cambodian border.<sup>8</sup> Other concerns were expressed as well: from the State Department, which was worried about the possible entry of the Soviet Union and the People's Republic of China into the war, and from SAC, which was concerned about the drawdown effects on its nuclear capability.<sup>9</sup> Nevertheless, General Westmoreland made a strong case for their use to supplement the efforts of tactical fighters that could not provide the systematic, large scale, pattern bombing laydowns needed. Eventually the JCS approved General Westmoreland's request.

### *Rolling Thunder*

The Rolling Thunder bombing campaign against North Vietnam followed an earlier, largely naval air effort, called Operation Flaming Dart, to hit targets in North Vietnam. Flaming Dart had been planned as a "graduated reprisal program" of retaliatory air strikes against possible Viet Cong provocations.<sup>10</sup> Unfortunately, it did not prove successful in deterring the Viet Cong from further attacks; consequently, it was decided that a more sustained bombing campaign was required. Rolling Thunder was authorized on 13 February 1965 by President Johnson, initiated on 2 March 1965, and continued until 1 November 1968. However, Rolling Thunder was unsuccessful as well, and suffered from employment constraints as well as command disagreements over its objectives. Operations were conducted under strict controls and guidance from Washington—in other words, "targeting by remote control."<sup>11</sup> The degree of control is illustrated by the following quote:

... As on the previous occasions, commanders were told on which day to strike; in many cases they were told the hour of attack (which ignored weather conditions). They were told by Washington the number of sorties by task and by target; the type, number, and fuzing of weapons to be used; and, sometimes, even the direction of attack. Attacks were limited to primary targets or one of two alternates. Unexpended ordnance had to be dumped into the South China Sea. Pre-strike reconnaissance was not permitted. Bomb damage assessment (photographic) aircraft were to accompany strike aircraft or follow them immediately; subsequent bomb damage assessment was to be conducted by these aircraft, unescorted, flying at medium altitudes only. No aircraft was to be re-loaded and

<sup>7</sup>Quoted in Schligh, pp. 104–105.

<sup>8</sup>Schligh, p. 105.

<sup>9</sup>Schligh, pp. 49–50.

<sup>10</sup>Mark Clodfelter, *The Limits of Air Power: The American Bombing of North Vietnam*, The Free Press, New York, 1989, p. 57.

<sup>11</sup>Cagle, VADM, Malcolm W., USN, "Task Force 77 in Action off Vietnam," *United States Naval Institute Proceedings*, 1972, in Frank Uhlig, Jr., ed., *The Naval Review*, 1972, p. 73.

returned for a second attack. If the target weather was bad on the approved day, the mission could not be rescheduled without repeating the elaborate process of gaining approval from Washington. Enemy aircraft had to be positively identified before shooting, a tough requirement for aircraft flying at Mach 1. Rules were so stringent that only military trucks could be hit, and these had to be moving on highways, not parked in villages. (Later this rule was relaxed to allow trucks within 100 meters, and later still, within 300 meters, of the roads to be attacked, but never in the village sanctuaries. No one explained to the pilots how to distinguish a *military truck from a nonmilitary one*.<sup>12</sup>

While working out operational issues between air and naval forces, the concept of "route packages" (RPs) was employed, a scheme that remained in use for the remainder of the war. North Vietnam was divided into six areas; Route Package VI was divided further into two, VI-A and VI-B (Figure 3.3).

The assignment of route packages was based largely on the respective operational range of Navy and Air Force aircraft and was made as follows:

1. Route Packages I, V, and VI-A to the Air Force: the latter two being the northernmost zones including Hanoi and the Northwest Railroad
2. Route Packages II, III, IV, and VI-B to the Navy: an area extending from the 18th Parallel to the PRC and included Haiphong and part of the Northeast Railroad

In addition, COMUSMACV was given authority to schedule strikes in Route Package I immediately north of the DMZ.<sup>13</sup>

While the route package system appeared to be a workable compromise, in actuality it limited the operational effectiveness of the Rolling Thunder campaign. Weather cycles over North Vietnam and limitations on the geographical area of flight, coupled with concern for collateral damage, forced pilots to use specific air corridors at specific times for both ingress to and egress from their targets. Consequently, as B-52 crews were to discover later in Linebacker II, the resulting stereotypical tactics enabled the enemy to employ his AAA very effectively against the bombers.<sup>14</sup> As recounted by 2d Air Division Commander LtGen Joseph H. Moore in 1969, "I resisted [the division of North Vietnam into separate Air Force and Navy zones] quite bitterly for a long time

<sup>12</sup>Cagle, pp. 73–74. Italics in original.

<sup>13</sup>Clodfelter, p. 129.

<sup>14</sup>Berger, Carl, ed., *The United States Air Force in Southeast Asia, 1961–1973: An Illustrated Account* (rev. ed.), Office of Air Force History, United States Air Force, Washington, D.C., 1984, p. 75.

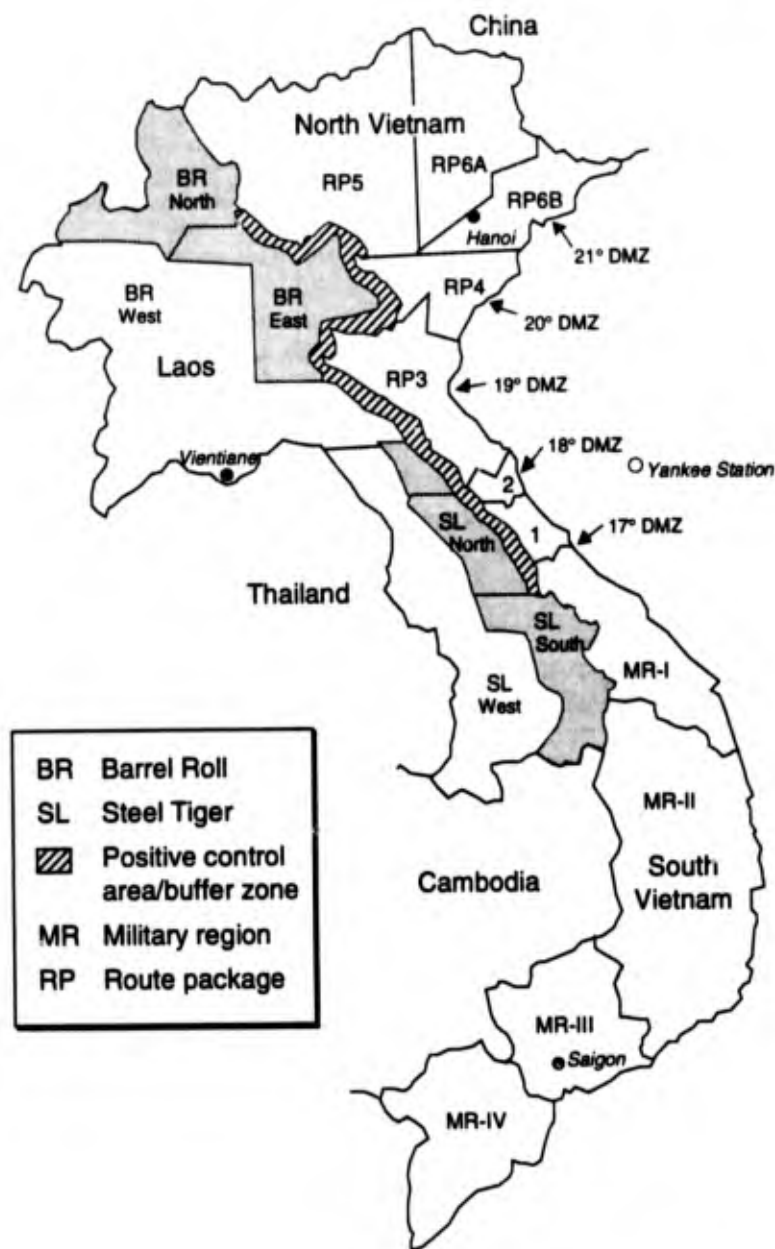


Figure 3.3—Southeast Asia, Area of Combat Operations

because it ended up with us [the Air Force] going to be up around the highly defended areas, and I thought we ought to share that privilege with the Navy.<sup>15</sup> Furthermore, although each service was allowed to attack targets within the

<sup>15</sup>USAF Oral History interview of Lt Gen Joseph H. Moore by Maj Samuel E. Riddlebarger and Lt Col Valentino Castellina, 22 November 1969, AFHRC (Air Force Historical Research Center), file number K239.0512-241, pp. 17–18, cited in Clodfelter, p. 129.

other's route package, it occurred rather infrequently and required permission from the service responsible for the RP.

By the time Rolling Thunder ended in November 1968, 304,000 tactical sorties by the air arms of all the services and 2380 B-52 sorties had dropped 643,000 tons of bombs on North Vietnam's war-supporting industry, transportation network, and air defense system.<sup>16</sup> These statistics, however, belie the effectiveness of the campaign in achieving its objectives of reducing the flow of troops and supplies from the North to the South and ultimately ending the war.

## **Air Interdiction and Close Air Support: The Defense of the Marine Base at Khe Sanh, South Vietnam**

### ***Background***

The defense of the Marine base at Khe Sanh in early 1968 represented a major tactical success for the United States. Yet the outcome of the Tet Offensive, for which the attack on Khe Sanh served as a feint, had a far greater impact in terms of contributing to the impetus for the American withdrawal from Vietnam. The Tet Offensive was begun nine days after Khe Sanh was attacked and continued until the end of March 1968. As a concerted, all-out effort by the North Vietnamese against U.S. and Allied forces throughout the South, Tet was blunted, largely by air power, and the North's hoped-for collapse of the South Vietnamese government did not occur. Nevertheless, U.S. public perception of the Tet Offensive as a U.S. defeat contributed to the push for withdrawal.<sup>17</sup>

Operation Niagara was the concentrated U.S. air response to the Tet Offensive. Its purpose was to disrupt enemy efforts in northwestern I Corps of South Vietnam and the contiguous area of Laos. It utilized tactical air elements from every service and included SAC B-52s employed in close air support and air interdiction roles. Because intelligence reports indicated that an attack of an extremely large magnitude was going to be launched, MACV and its component forces were able to identify and agree on an appropriate air strategy, i.e., conduct a sustained, coordinated bombing campaign to disrupt the enemy and forestall the offensive.<sup>18</sup> Specific targets for the air campaign included North Vietnamese attack points and patrol and supply lines.

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<sup>16</sup>Berger, p. 89.

<sup>17</sup>Communication to the author from Bernard C. Nalty, Office of Air Force History.

<sup>18</sup>Schlicht, p. 277.

When the North Vietnamese launched their attack against the Marine base at Khe Sanh on 21 January 1968, the U.S. air response was swift. Nearly 600 tactical sorties, including 49 B-52 sorties, were made against enemy positions that day alone. Figures 3.4 and 3.5 illustrate the comparative sortie levels of each of the services in Operation Niagara. By the end of the operation two months later, more than 24,400 tactical strike sorties and 2700 B-52 sorties had been conducted, dropping 110,000 tons of ordnance.<sup>19</sup> Forward air controllers (FACs) flew more than 1500 sorties and reconnaissance planes approximately 1400 sorties.<sup>20</sup> The monsoon weather played a major role in air operations, forcing most aircraft to rely on "Combat Skyspot" radar.<sup>21</sup> The tactical airlift provided by USAF C-130s was critical as the base was surrounded by North Vietnamese and Viet Cong forces. Because of standard cargo extraction techniques, the C-130s were able to drop their cargoes over the airfield without touching down, thus limiting their vulnerability to enemy fire.<sup>22</sup>

While fighter aircraft hit enemy positions in the immediate environs of the base, B-52s from Guam and U Tapao conducted operations against enemy supply and storage areas further out.

### *Operations and Tactics*

Many operational issues were driven by the problems of coordinating attacks conducted by each service in the theater. The Marines developed a "fire zone defense" around the base (see Figure 3.6) that served to divide the coordination and control of air and artillery support between the Marines and the 7th Air Force. The Marines retained control of artillery and fire support of those zones immediately around the base, while fire control of those zones on the periphery of the base was delegated to the 7th Air Force's Airborne Battlefield Command and Control Center (ABCCC), a converted C-130 aircraft.<sup>23</sup> B-52s conducted the air interdiction campaigns from Kadena AFB, Okinawa, U-Tapao Royal Thai Navy Airfield, Thailand, and Andersen AFB, Guam, against targets near Khe

<sup>19</sup>Trest, Warren A., *Project CHECO: Khe Sanh (Operation Niagara), 22 January–31 March 1968*, HQ PACAF, Directorate, Tactical Evaluation, CHECO Division, 13 September 1968, (declassified), p. 1; Berger, p. 52.

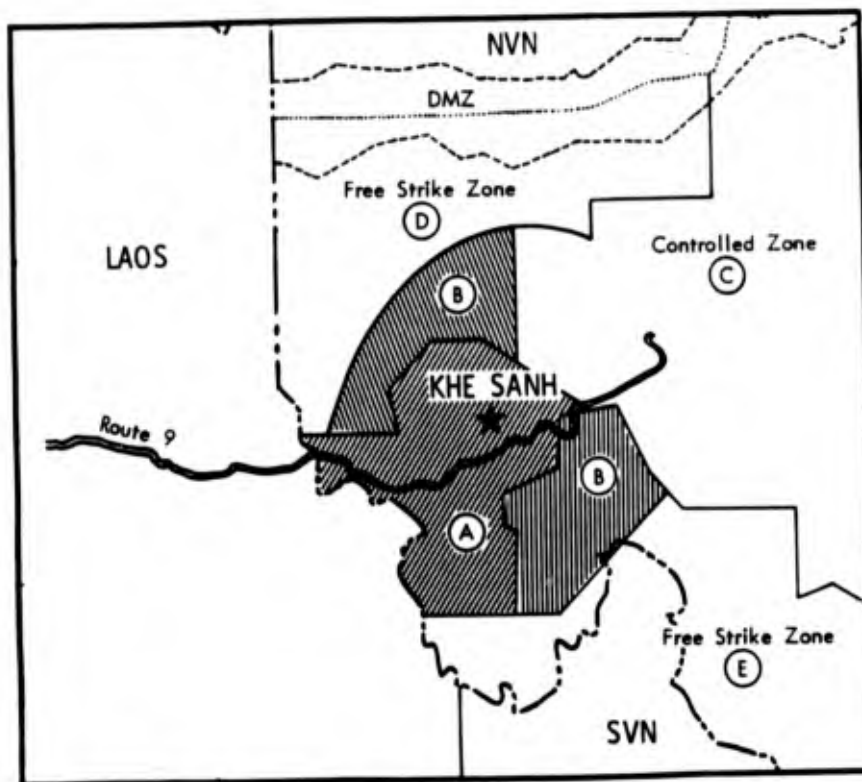
<sup>20</sup>Schlight, p. 285, footnote 81.

<sup>21</sup>Skyspot was a ground-based radar used to direct aircraft to unseen positions at night or in poor weather; however, because of some technical problems, it was used many times only as a backup to the FACs. Five sites scattered throughout South Vietnam were able to cover the entire country.

<sup>22</sup>Communication to the author from Bernard C. Nalty, Office of Air Force History.

<sup>23</sup>Schlight, pp. 277–278; Nalty, p. 73.





- A-B Restricted fire areas. Air and artillery support coordinated and controlled by the Marines at Khe Sanh.
- C Restricted fire areas. Air and Artillery support coordinated and controlled by the Marines at Dong Ha.
- D-E Free strike zones. Air strikes controlled by the 7th Air Force Airborne Battlefield Command and Control Center.

SOURCE: Nalty, Bernard C., *Air Power and the Fight for Khe Sanh* (Office of Air Force History, United States Air Force, Washington, D.C., 1986), p. 75.

Figure 3.6—Marine Corps Position on Command and Control, Khe Sanh, January 1968

Sanh and in Laos. To increase the weight of ordnance dropped in support of the Marines, new operational procedures, called "Bugle Note," were adopted by LtGen Selmon W. Wells, USAF, Commander of the 3d Air Division based on Guam. Bugle Note entailed a grid system overlaid on a map of the Niagara area, with each block representing a  $1 \times 2$  km box covering an area that a three-aircraft cell of B-52s could effectively target. On a prearranged schedule (initially 90 minutes apart but later varied to confuse the enemy), a cell would arrive at a specified point where a Combat Skyspot could direct it to its aiming point. Each cell had an alternate target if it could not hit its primary target. Later, the procedure was changed to allow six B-52s every three hours rather than three aircraft every ninety minutes, largely to increase target coverage but also to

decrease maintenance times and to allow for post-strike bomb damage assessments.<sup>24</sup>

SAC also was able to provide alternately six or nine sorties per day from Korean contingency resources—aircraft stationed at Kadena AB, Okinawa—“subject to JCS approval and availability of weapons.” General Westmoreland ordered, and received approval from Admiral Sharp for, two additional strikes of six aircraft per day. Thus, for Operation Niagara, with the Korean forces included, 48 B-52 sorties were devoted to the effort—16 missions per day with three aircraft each over the target every 90 minutes.<sup>25</sup>

While interdiction of enemy forces and supply lines was not a problem, because of the proximity to the Marine defenders, initially bomber operations were constrained by 3-kilometer safety zones in the immediate vicinity. Quite by accident, however, the Marines found that bombing by the B-52s could take place much closer to Marine lines than previously thought. Before Operation Niagara, in November 1967 while on a routine mission to hit troop concentrations and rocket batteries near Con Thien, a B-52 accidentally dropped bombs within 1.4 kilometers of the Marine lines. When secondary explosions resulted, it was discovered that the NVA was taking advantage of the safety zones. Consequently, there was increased pressure from COMUSMACV to use the bombers in close air support roles in defense of Khe Sanh. While Marine and SAC leaders were reluctant to conduct bombing operations inside the safety zones except for emergencies, they agreed to a series of tests which would bring the salvos to within 1 kilometer from friendly forces. These tests proved successful, and close air support operations were approved by CINCPAC, Admiral Sharp, in mid-February 1968.<sup>26</sup>

The reactions of both Marines and enemy to the use of B-52s in close air support are notable. One account relates that the sight of hundreds of bombs exploding almost simultaneously brought some Marines out of their bunkers to cheer the B-52s.<sup>27</sup> In another account, a Marine ground commander observed the reactions of both U.S. and NVA troops to two successive strikes:

All in the area were awed at the devastating accuracy and destruction displayed by your pilots and weaponry. For the past two weeks enemy activity in and around the target has been such that our ground operations have been exposed to continual harassment. It is my belief that today these

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<sup>24</sup>Nalty, pp. 82–83.

<sup>25</sup>Trest, pp. 68–69.

<sup>26</sup>Nalty, pp. 83–86; Trest, p. 70.

<sup>27</sup>Nalty, p. 86.

enemy forces were struck a blow so severe as to render them ineffective for an appreciable period.

A large number of NVA troops were observed actually running from the bombed zone following the first strike. They seemed oblivious to anything but putting distance between themselves and the oncoming bombs. Consequently, all were travelling in the same direction and at the same speed presenting a very tight, compact target. Observers witnessed one bomb of the second strike score a direct hit on the group which, needless to relate, utterly disappeared.<sup>28</sup>

### ***Bombing Results***

From an historical perspective, the defense of Khe Sanh was successful, perhaps because of the enormous numbers of resources devoted to defending it. Many U.S. political and military leaders saw this as the American Dien Bein Phu and were determined not to repeat the French experience. Nevertheless, it tied up American air assets for more than two months, which had an effect on the use of air power in other parts of South Vietnam.

Table 3.1 shows the records kept of the bombing effort.

The actual effects of the B-52 bombing were difficult to determine. Usually an aerial camera was used to record bomb damage assessment (BDA), but because

**Table 3.1**  
**Bombing Statistics**

Division	Sorties	Bombs (tons)
7th Air Force	9,691	14,223
3d Air Division's B-52s	2,548	59,542
1st Marine Aircraft Wing	7,078	17,015
Naval Aviation	5,337	7,941
<b>Bombing Effects</b>		
Secondary explosions	4,705	
Enemy killed	1,288	
Structures destroyed	1,061	
Structures damaged	158	
Bunkers destroyed	891	
Bunkers damaged	99	
Trucks destroyed	253	
Trucks damaged	52	

SOURCE: Trest.

<sup>28</sup>Trest, pp. 70-71.

of several factors, only about 7 percent of *all* B-52 strikes in the theater were observable and accountable. Poor visibility, the first factor, was caused by daytime weather conditions; scheduling half the strikes at night; and smoke, dust, and dense foliage. The second factor was the sheer density of the bombs (not only from both B-52 strikes but also from artillery fire and tactical air strikes in the same locations) in each target box that obliterated the target area and made assessments difficult by any method other than Marine foot patrols.<sup>29</sup>

Despite the figure for enemy killed shown in Table 3.1, the actual number of those killed directly by the bombardment was impossible to determine. Later reports gave the "most reasonable estimate" as being 10,000 enemy casualties (killed and wounded). If true, this number would represent 59 percent of the total number of enemy killed in all of I Corps during the Tet Offensive.<sup>30</sup> Furthermore, the effects of the bombing on the NVA soldiers themselves varied greatly, given that some post-attack reports recounted numerous desertions, while others cited captured enemy soldiers as saying they had warning of the attacks, possibly from Soviet trawlers or from interception and decoding of messages from Tan Son Nhut.<sup>31</sup> Nevertheless, General Westmoreland was very pleased with the results of the bombing and said that "the thing that broke [the enemy's] backs was basically the fire of the B-52s."<sup>32</sup>

Interpretations vary as to the enemy's view of the importance of Khe Sanh to the Tet Offensive. While the numbers of artillery and antiaircraft guns and the deployment of two NVA divisions were indicative that the attack on Khe Sanh was a major effort, other tactics the North might have been expected to take against the Marines did not materialize.<sup>33</sup> For the United States, the successful defense of the base was in sharp contrast to the overall reaction of the Johnson administration and the public to the Tet Offensive. Just as the defense of Khe Sanh was concluding, President Johnson announced a cessation of American attacks on North Vietnam except in the North Vietnam panhandle north of the DMZ and said he would not seek reelection. Nevertheless, it is likely that had the U.S. military not devoted the effort and resources to defending the base, it would have been overrun, and the consequences would have been far greater for

<sup>29</sup>Nalty, pp. 86–88; Trest, p. 91.

<sup>30</sup>Emphasizing the speculative nature of the numbers quoted, Nalty (p. 103) says that this figure was 3,000 more than those killed at Hue and was 27 percent of total NVA and Viet Cong dead in all of South Vietnam during Tet.

<sup>31</sup>Nalty, pp. 86–88; Trest, pp. 92–93. Dr. Jack Shulimson of the Marine Corps History Office states that recent evidence has raised doubt that two North Vietnamese divisions actually massed at Khe Sanh. Communication to the author by Bernard C. Nalty, Office of Air Force History.

<sup>32</sup>Quoted in Nalty, p. 88, and Berger, p. 157.

<sup>33</sup>These tactics would have included cutting off the water supply to the base, digging tunnels, or building siege trenches earlier than late February when they were observed. Nalty, p. 105.

both the U.S. military presence and the survival of the South Vietnamese government.

## Strategic Bombardment: The Linebacker Bombing Campaigns over North Vietnam

### *Background*

Linebacker II was preceded by Rolling Thunder and Linebacker I, which were interdiction in intent and directed against enemy logistics lines throughout Southeast Asia. Linebacker I was initiated in the spring of 1972 and ended on 22 October 1972 when a bombing halt was implemented above 20 degrees north latitude. Strike operations against NVN targets below the 20 degree north line continued until the start of Linebacker II on 18 December. Linebacker II was begun largely as a result of a change in the political and diplomatic situation. It covered an 11-day period—from 18 to 29 December 1972—of sustained bombardment against targets in North Vietnam. The purpose of the campaign was to bring the North Vietnamese to the conference table so that the United States could exit the war in some sort of face-saving way.<sup>34</sup> Tactical objectives for U.S. air power were to destroy NVN domestic war-related resources; to reduce/restrict NVN resupply by air from foreign sources; and to interdict the movement of men and supplies into South Vietnam and Laos. Although the B-52s received most of the spotlight, like Rolling Thunder and Linebacker I, Linebacker II was a joint operation: in addition to B-52s from U-Tapao and Andersen AFB, the operation employed F-111s in preemptive strikes against enemy defenses; F-4s spread chaff; and EB-66s, EA-3s and EA-6s conducted electronic countermeasures (ECM) activities. F-105s, F-4s and A-7s accompanied the bombers to defend them against ground and air defenses.<sup>35</sup>

This subsection will first examine Linebacker I targeting priorities and how they led to the priorities established for Linebacker II. Next, an overview of the

<sup>34</sup>This purpose differs from the goal stated in a Project CHECO report on Linebacker operations, September to December 1972, that stated that "The overall goal of Linebacker, like the old Rolling Thunder bombing and interdiction campaign over NVN between 1965 and 1968, was to bring sufficient pressure on the NVN government so that it would stop its open aggression and support of insurgent operations in South Vietnam, Laos, and Cambodia." (See Major Calvin R. Johnson, *Linebacker Operations September-December 1972*, Project CHECO Office of History, HQ PACAF, 31 December 1978, p. 3 [declassified].) Measured against this goal, the Linebacker II campaign would be considered of no real significance. On the other hand, measured against the purpose stated above, the campaign would be considered successful. The author is indebted to Glenn Kent for clarifying this point.

<sup>35</sup>The ratio of support aircraft to bombers averaged 1.3 to 1. McCarthy, James R., BrigGen, and Allison, LtCol George B., authors; Col Robert E. Rayfield, ed., *LINEBACKER II: A View From the Rock*. USAF Southeast Asia Monograph Series, Volume VI, Monograph 8. Airpower Research Institute, Air War College, Maxwell AFB, AL, 1979, p. 139.

phases of the December campaign is presented, followed by a discussion of operations and tactics, and then B-52 attrition and losses. The subsection concludes with an assessment of bombing results and the campaign's effect on the prosecution of the war.

### ***Linebacker I Target Priorities***

During Linebacker I, targeting priorities were established, and were supported by both tactical aviation and B-52 bombers. The three targeting priorities are given below:

#### **Priority I: Land/Water Lines of Communication**

- A. Rail and highway bridges between the PRC and the Hanoi-Haiphong restricted<sup>36</sup> areas.
- B. Other rail and highway bridges.
- C. Choke points/transshipment points.
- D. LOC construction vehicles, equipment, locomotives, rolling stock, watercraft, and concentrations of trucks and other vehicles.

#### **Priority II: Petroleum, Oil, and Lubricants (POL) System**

- A. POL resupply from [the] PRC, related storage/support facilities, and distribution systems.
- B. Dispersed POL storage/[support] facilities.

#### **Priority III: War-Supporting Systems**

- A. Military supplies.
- B. Vehicle/equipment repair facilities.
- C. Military installations.
- D. Construction materials and equipment.
- E. Ship-building facilities.
- F. Industrial plants.

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<sup>36</sup>Hanoi/Haiphong restricted areas covered those targets within ten nautical miles of Hanoi and five nautical miles of Haiphong that had to be validated specifically by the JCS before strike. At times, no strikes were allowed within these restricted areas.

G. Command and control.

H. Electric power.<sup>37</sup>

North Vietnamese defense installations, such as air defense systems, coastal defense systems, and command, control, and communications (C<sup>3</sup>) associated with both, would be "attacked as necessary to provide maximum freedom of action [and] safety for friendly strike and reconnaissance forces operating against validated/authorized targets. . . ." <sup>38</sup> However, in August 1972 the Chairman of the JCS, Admiral Moorer, argued for greater emphasis on striking those targets in the northern Route Packages, and that "[B-52 strikes] can be employed profitably in NVN. . . . In addition to the significant military results, periodic B-52 raids into the NVN heartland would forcefully demonstrate the seriousness of our intentions to the Hanoi leadership. . . ." <sup>39</sup> Accordingly, greater priority to attacking targets in Route Packages 5 and 6, using those USAF and USN air assets appropriate for the range, capability, and weather.

In the fall of 1972 the targeting priorities were realigned along geographical rather than functional lines:

Priority I:

- A. Rail and highway bridges (authorized for strike) in RPs 5, 6A, and 6B.
- B. Choke points [and] transshipment points (authorized for strike) in RPs 5, 6A, and 6B.
- C. Concentrations of locomotives and/or rolling stock between the PRC buffer zone and Hanoi/Haiphong restricted zones.

Priority II: Lines of communication and transportation in Route Packages 1-4, including:

- A. Rail and highway bridges.
- B. Choke points, transshipment points.

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<sup>37</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, pp. IV-13-IV-14.

<sup>38</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, p. IV-14.

<sup>39</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, pp. IV-14-IV-16.

- C. LOC construction vehicles and equipment, other locomotives and rolling stock, watercraft, and concentrations of trucks and other vehicles.<sup>40</sup>

POL targets were moved from Priority II to Priority III because of the lack of success of the air strikes against them; also, war-supporting systems were lowered from Priority III to Priority IV.<sup>41</sup>

While Linebacker I continued, planning for a sustained bombing campaign such as Linebacker II was begun, with SAC's B-52s being central to the effort. The B-52 was selected as the lead aircraft for any sustained bombing campaign because of the expected weather over North Vietnam—the monsoon season was about to start; the aircraft's all-weather radar bombing capability was critical to achieving the required damage effectiveness. Furthermore, the use of the B-52 had psychological aspects as well—its strategic nuclear role signified American determination in a way no other aircraft could. In September 1972, the 7AF proposed a "Conceptual Targeting Plan for a Coordinated and Sustained Air Campaign Against NVN." It envisioned a 36-day B-52/tacair effort against high-value targets in the North's heartland to achieve a 70-percent level of destruction. The tasks for the plan were to suppress enemy air defenses and then destroy the NVN's ability to fight. Target priorities were (1) air defense and storage facilities and (2) selected POL, transportation, industrial, rail and highway targets. As Linebacker II was eventually implemented, it differed from the 7AF plan by having a greater number of sorties in a shorter period of time and by pursuing targets concurrently.<sup>42</sup> The target classes chosen for Linebacker II were railroad yards, storage facilities, radio communication (RADCOM) facilities, power facilities, airfields, SAM sites, and bridges. Specific targets and sorties fraged during Linebacker II are shown in Table B.2.

### *Phases of Linebacker II*

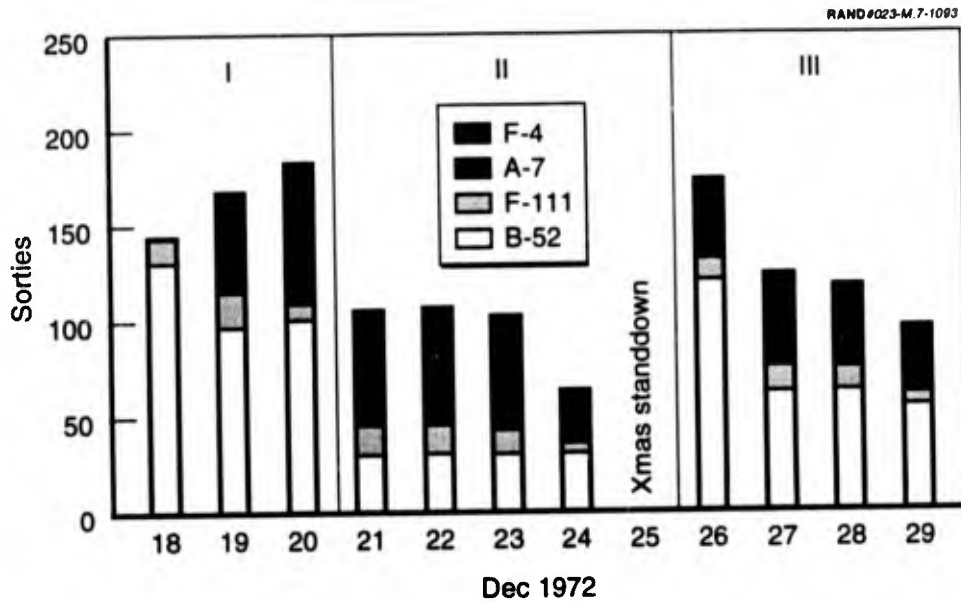
The three phases of the operation are shown in Figure 3.7.

- 18–20 December
- 21–25 December (25 December was the 36-hour Christmas standdown)
- 26–29 December.

<sup>40</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, pp. IV-19–IV-21.

<sup>41</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, pp. IV-209–IV-210.

<sup>42</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, p. IV-21.



SOURCE: Col Herman L. Gilster and Capt Robert E. M. Frady, HQ, Pacific Air Forces, Linebacker II USAF Bombing Survey, April 1973 (Declassified).

Figure 3.7—Phases of Linebacker II and USAF Strike Sorties

During the first phase, the bombing effort was directed against the Hanoi area. Three B-52 waves were used each night, and tactical fighter and fighter-bomber forces from the 7th Air Force were used during the day. During the second wave, a reduced sortie effort was directed against the northeast rail line; in the last phase, single waves were sent against Hanoi and Haiphong targets. Summary data on Linebacker II are included in Table B.2 by day, wave, total number of aircraft, originating base, and losses.

### *Mission Planning, Targeting, and Coordination*

Mission planning, targeting, and coordination of B-52 strikes were affected by operational targeting decisions made by SAC planners in Omaha (and were certainly influenced by decisionmakers in Washington). SAC recommended targets, weight of effort, and time on target, and their recommendations were authorized by the Joint Chiefs of Staff. Weaponeering also was done at SAC. As noted in a *Corona Harvest* report produced by Headquarters, Pacific Air Forces (PACAF),

After receiving the CINCSAC's approval, the weaponeering data for each day's targets was sent to Headquarters 8AF at Andersen AFB, Guam, for inclusion in the daily mission frag orders. 8AF planners, with Headquarters SAC assistance, were responsible for the ingress/egress headings and selection of most of the offset aiming points (OAPs) that would be used for navigation to the targets and then bomb release. OAP selection was critical since all bombing would be synchronous by radar using the AN/ASQ-38 bomb/navigation system (BNS) of the B-52Gs and the AN/ASQ-48 of the Ds.<sup>43</sup>

Coordination for the B-52 strikes evolved over the 11-day campaign. Initially, SAC set the B-52 sortie and target application, but on 21 December it was modified to have CINCSAC coordinate with CINCPACAF, as CINCPAC's representative, on targets, timing and weight of the effort in North Vietnam exclusive of Route Package 1. On 23 December, CINCPACAF formally delegated this authority to 7AF.<sup>44</sup> Before the Christmas standdown, the CINC 7AF sent a request to CINCSAC (and CINCPACAF) for more timely B-52 mission data to adequately plan effectively for missions:

Often we receive final information on ingress, egress, spacing between cells, etc. after our frag should have been disseminated. This severely constrains us in planning optimum tactics, and the end result is the Wings have inadequate time to prepare for their missions.<sup>45</sup>

He requested that for each B-52 mission CINCSAC set a separation of at least 20 hours between times on target (TOTs) from one frag day to another; and target selection, TOT, cell structure, timing, ingress/egress routes, axis of attack, and cell call signs at least 18 hours before TOT. CINCSAC said in reply that SAC would do all it could to provide that information but that occasionally other factors might cause unavoidable delays.<sup>46</sup>

SAC had its own concerns about the B-52 operations. In a post-campaign evaluation of the risks posed to the B-52s during Linebacker II, CINCSAC was concerned about the delay imposed by the JCS in targeting SAM sites that posed a threat to the Arc Light missions. His view was reflected in a message sent to CINCPAC on 6 January 1973:

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<sup>43</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972-15 August 1973*, Vol. V, p. 8.

<sup>44</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, p. IV-308.

<sup>45</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, p. IV-308.

<sup>46</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, p. IV-309.

Hanoi Quin Loi storage facility, containing what appeared to be [a] substantial quantity of SAM missile canisters and associated equipment was found on reconnaissance photography and recommended by SAC for strike by TACAIR and B-52s. This recommendation was made on 24 December 1972. It was on the 26th that authorization was received for TACAIR strikes and 28 December that TACAIR struck the target. B-52s were never authorized to attack it. This delay, for whatever reason, in striking this target probably had some influence on the relative risk to B-52 and TACAIR crews from the terminal defenses south of the Red River. . . .<sup>47</sup>

A CINCPACFLT assessment also identified specific problems, such as short-notice mission tasking (especially when it stated explicitly "regardless of the weather"), bombing halts that allowed for a buildup of enemy defenses, last-minute changes in target assignments, and limited authority delegated to the on-site commander to flexibly allocate his resources in light of weather, terrain, and other factors.<sup>48</sup> The biggest restriction on targeting, however, was the requirement to "adjust strike tactics to minimize civilian casualties, to avoid third country shipping and to remain clear of the PRC Buffer Zone."<sup>49</sup> Unfortunately, these restrictions hindered safe operating procedures and effective targeting operations; furthermore, the enemy knew the restrictions as well and adjusted his strategy and positioned his defenses accordingly.<sup>50</sup>

Finally, the coordination problems were solved, at least temporarily, when CINCPAC promulgated new target validation and mission planning procedures. As of 27 December 1972, all target validation requests from CINCPAC, Commander in Chief, Pacific Fleet (CINCPACFLT), and SAC were to be forwarded to CINCPAC who would review and validate those targets in his area of responsibility and pass them on to the JCS. All mission planning requests were to go directly from CINCSAC to CINC 7AF, who would then coordinate with 7th Fleet through the Air Coordinating Group (Saigon).<sup>51</sup>

<sup>47</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, p. IV-269.

<sup>48</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, pp. IV-269-IV-270.

<sup>49</sup>The PRC Buffer Zone was a strip of territory in North Vietnam next to the People's Republic of China (PRC) border, in which American aircraft were not allowed to operate without specific, prior approval from the JCS.

<sup>50</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, p. IV-270.

<sup>51</sup>HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia 1 July 1972 to 15 August 1973*, Vol. II, p. IV-310.

## *Operations and Tactics*

Linebacker II missions were characterized by “compression” tactics and “press-on” rules of engagement. Compression referred to the technique of flying three cells of three aircraft each attacking the same target area with up to a ten-minute separation between cells. This technique was used to suppress enemy defenses and to simplify the countermeasures problem. “Press-on” meant that the aircraft were to continue to the target regardless of the level of SAM or MiG threat and independent of aircraft systems degradation.<sup>52</sup> It represented a change in safety rules from Linebacker I and earlier operations where the aircraft commander could decide to abort the mission if his aircraft was experiencing mechanical or other problems or if SAMs were encountered. In Linebacker II the loss of two engines or the malfunctioning of the bombing computers, radar, defensive gunnery, or ECM capability were not sufficient for aborting the mission. Because of these rules, only two aborts occurred at Andersen during the entire 11 days: (1) on 26 December when four engines on one wing had to be shut down soon after takeoff and (2) on 29 December when the refueling system had a total breakdown.<sup>53</sup>

Collateral damage was a political concern that directly affected mission planning. Accordingly, restrictions initially were placed on attacking enemy defenses because of their proximity to civilian centers. Coupled with the “press-on” rules of engagement, bomber survivability was affected and was a source of frustration to the crews. Collateral damage also was a factor in deciding how to dispose of “hanger” bombs that were not dropped on the target: they were carried until they could be dropped in the ocean or in some other cleared bomb drop area.<sup>54</sup>

*Sorties.* Bomber sorties were conducted at night at altitudes above 32,000 feet to take advantage of the B-52’s all-weather capability and to prevent tracking by North Vietnamese air defenses.<sup>55</sup> Sortie flight times varied depending on type of aircraft (for range, refueling, and weapon loading capabilities) and the base from

<sup>52</sup>McCarthy and Allison, pp. 30–32.

<sup>53</sup>McCarthy and Allison, p. 32.

<sup>54</sup>Flights from U-Tapao dropped their “hangers” armed over the Gulf of Siam where they would explode on impact with the water. This method was requested by the King of Thailand so as to avoid having live bombs wash up on Thailand’s beaches. Conversation with Maj John Graham, USAF (ret.).

<sup>55</sup>Testimony of ADM Thomas H. Moorer, Chairman, JCS, on the Bombing of North Vietnam, in *Hearings Before Subcommittees of the Committee on Appropriations, House of Representatives, 93rd Congress, First Session, 9 January, 1973*, p. 21; PACAF, with SAC, *Corona Harvest: USAF Air Operations in Southeast Asia, 1 July 1972–15 August 1973, Linebacker II–SAC Operations, Vol. V, Addendum* (declassified), pp. 9–10. North Vietnamese air defenses consisted of early warning (EW) and ground-controlled intercept (GCI) radar networks, MiG fighters, SAM missile sites, and AAA weapons.

which the aircraft was launched. From U-Tapao, the flight averaged 3-1/2 hours, with no refueling, and the crew duty day was about eight hours. In contrast, the sortie flight time from Andersen AFB on Guam lasted about 12 hours and required prestrike refueling; the crew duty day was about 17 to 18 hours. Furthermore, these aircraft were forced to carry fewer munitions. Weapons numbers and loading by aircraft type are shown in Table 3.2.

Missions from both bases were timed to coincide over the targets. Thus the crews from U-Tapao had to wait about five hours after their crew briefing before taking off in order to coordinate their timing with the Andersen crews, a wait that undoubtedly caused a fair amount of anticipation as well as trepidation of the impending mission.<sup>56</sup>

Flying from Guam obviously had a greater impact on supporting resources, especially tankers; also a number of KC-135s were deployed to Okinawa to support the bombers at Andersen. Later, tanker support was expanded to include bases in the Philippines and Thailand.<sup>57</sup>

Almost all the fragged routes to the targets were planned to take advantage of the high prevailing tail winds prevalent during that time of the year. Cells of three aircraft each were organized into a trail two nautical miles and fifteen seconds apart with a 500-foot separation between the aircraft. Cell leaders were placed two minutes apart nose-to-tail, with a 2000-foot altitude separation

**Table 3.2**  
**Number and Type of Weapons by**  
**Aircraft Type and Location**

Aircraft/Base	Internal Load	External Load
B-52G/Andersen	27 M-117	—
B-52D/U-Tapao	42 M-117	24 MK-82
B-52D/U-Tapao	84 MK-82	24 M-117
B-52D/Andersen	42 MK-82	24 MK-82

SOURCE: PACAF, with SAC, *Corona Harvest: USAF Air Operations in Southeast Asia, 1 July 1972 to 15 August 1973, Linebacker II—SAC Operations*, Vol. V, Addendum (declassified), p. 9.

NOTE: The Mark 82 (MK-82) 500-pounder and M-117 750-pounder were standard types of general purpose bombs.

<sup>56</sup>Conversation with Maj John Graham, USAF (ret.).

<sup>57</sup>McCarthy and Allison, p. 12; *Corona Harvest*, Vol. V, pp. 13-18.

between cells on the same track. The base altitudes for the cells varied from 34,000 to 38,000 feet.<sup>58</sup> Two or more cells using the same penetration corridor<sup>59</sup> and hitting the same target constituted a bomber stream. The actual number of cells in each stream was based on the weight of effort desired and tactical considerations. The axis of attack for each aircraft depended on such considerations as:

- The orientation of the target
- The ingress route from the west and/or northwest
- The availability of radar bombing offset aiming points (OAPs)
- The proximity of the targets to populated area
- Ground and air defenses.<sup>60</sup>

Route planning during Linebacker II was dictated by operational considerations such as collision avoidance but shifted dramatically after the heavy losses of the third and fourth days. In the early phases, bomber streams were organized into three waves per night approximately four hours apart so as to maximize the psychological effect. However, with this organization, the NVN could calculate arrival times and reload his defenses.<sup>61</sup>

Of interest is the following account of one strategic wing—the 307th Strategic Wing assigned to 17th Air Division (Provisional), 8th Air Force, based at U-Tapao—that details its participation in Linebackers I and II:<sup>62</sup>

The daily launch schedule between 1 October and 31 December 1972 consisted of 13 cyclic three-ship B-52 cells per day, each designated by a color, for a total of 39 aircraft plus spares scheduled for launch each day.

During Linebacker II, the 307th Strategic Wing flew 340 of 729 B-52 sorties logged by all 8th AF units. All were “press-on” types, with no allowances for aircraft systems degradation except where flight safety was affected. Compression tactics were used throughout (i.e., all cells scheduled for a particular mission were launched in rapid succession, with as little as a 2 to 10-minute separation between cells). During Linebacker II, the cell compressions varying

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<sup>58</sup>*Corona Harvest*, Vol. V, p. 11.

<sup>59</sup>The penetration corridor was provided by F-4s laying chaff within the lethal SAM line (LSL) from before the final dog leg turn into the target, through the target area, and out along the withdrawal route. The LSL was a 19-nautical mile arc drawn from an operational SAM site or a 24-nautical mile arc from a confirmed SAM operational area. *Corona Harvest*, Vol. V, p. 11.

<sup>60</sup>*Corona Harvest*, Vol. V, p. 12.

<sup>61</sup>*Corona Harvest*, Vol. V, p. 12.

<sup>62</sup>See Sgt Paul J. Gillette, USAF, *History of 307th Strategic Wing, October–December 1972*, Vol. 1.

in size from 6 to 42 aircraft were launched from U-Tapao. Some 27–30 B-52s could be launched in a 60-minute timeframe.

However, this mission compression caused problems:

- All crews were briefed on all targets, so they could roll forward if necessary once airborne. Manned spares also were kept informed
- Launches were complicated by an almost equal number of tankers that were launched simultaneously, in the darkness, which had impacts on safety
- Crew transportation to/from aircraft
- Fueling
- Maintenance inspection
- Minor repair of large numbers of aircraft leaving and arriving simultaneously.

The feeling, however, was that these problems were not insurmountable or unbearable. The compressions allowed bombers to take advantage of mutual ECM support, saturate enemy defenses, and penetrate enemy territory quickly. It also allowed as many as 100 B-52s to fly over a single target area at the same time.

***Munitions Effectiveness.*** The criteria for munitions effectiveness for Linebacker II were the same as that for a normal Arc Light mission. As one Corona Harvest report detailed:

An effective sortie was considered as one that (1) released at least 50 percent of its internal or external weapons load in an armed configuration; and (2) at least 80 percent of the released weapons impacted within the target area. During the period of LINEBACKER II, the latter criterion was difficult if not impossible to use. Thus, an effective sortie was one that released 50 percent of its external or internal load. However, this could mean that a B-52D from U-Tapao would be effective if it released only 12 M-117s of a B/A load of 24 M-117s and 84 Mk-82s. More applicable to LINEBACKER II operations was the previous effectiveness criteria of 50 percent of a sortie's weapon load released in an armed configuration.

On 18 December, one G and one D sortie failed to release more than half of their loads. On 19, 26, and 29 December, there was one sortie each day that did not release over one-half of its weapons. Thus, applying the 50 percent of weapons released armed criterion, the total number of bomb loads delivered on targets in North Vietnam amounted to 703 rather than the 708 obtained when using the 50 percent of externals or internals.<sup>63</sup>

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<sup>63</sup>Corona Harvest, Vol. V, p. 288.

Achieving the requisite munitions effectiveness was directly affected by weather, which for almost the entire campaign was bad and made bomb damage assessment difficult. The poor weather placed a heavy reliance on all-weather capable systems such as the B-52 and the newly deployed F-111 for bombing. For other tactical aircraft, exploiting any and all breaks in the weather was emphasized, especially for those aircraft carrying guided weapons. BDA was crucial as a counter to possible attempts by the North Vietnamese to generate public outcry against intentional damage to nonmilitary targets. It was also useful for evaluating different weapon systems against different types of targets.<sup>64</sup>

### *Bomber Attrition and Losses*

Figure 3.8 provides summary data on Linebacker II by day, wave, total number of aircraft, and originating base. Figure 3.9 illustrates both loss and damage information for the B-52Ds and B-52Gs. Of a total of 729 sorties (741 scheduled sorties), 15 bombers were lost, resulting in a 2-percent loss rate.<sup>65</sup> All B-52 losses were caused by surface-to-air missiles (SA-2 SAMs); the majority were hit on their post-target turn (PTT) after they had released their bombs. Only one, a B-52D on Day 7, sustained minor AAA damage. Table 3.3 illustrates SA-2 SAM firings and effectiveness against the B-52s.

It is interesting to note that despite more than 180 SAMs launched but with no aircraft losses and only some minor damage on Day 2, the SAC planners in Omaha decided to use the same attack plans and routing for Day 3 as on the previous two days.<sup>66</sup> Furthermore, they directed that no bomber should initiate maneuvers to avoid SAMs or fighters from the initial point (IP) on the bomb run to the target, approximately four minutes of stabilized flight. This directive was initiated because of a number of factors, including concern over the location of targets to population centers, the need to protect cell integrity for ECM support, and concern over potential mid-air collisions.<sup>67</sup> The result was that on Day 3 the NVN were able to determine the target routes and timing and to launch SAMs

<sup>64</sup>As General John W. Vogt, Jr., COMUSSAG/7AF, recounted on 28 May 1973, "I wanted to know precisely where every bomb had gone. . . . I can say with certainty that we knew where just about every bomb went in the two route pack areas. We persisted until we got the photography, even if it took a week or two." Quoted in Maj Calvin R. Johnson, *Project CHECO Report: Linebacker Operations September–December 1972*, Project CHECO, Office of History, HQ PACAF, 31 December 1978, pp. 69–70.

<sup>65</sup>Notably, this same percentage of attrition was suffered by the RAF from 1939 to 1945.

<sup>66</sup>This decision may have been made because the first two to three missions probably were "canned," i.e., preplanned.

<sup>67</sup>McCarthy and Allison, pp. 46–47; also conversation with Maj John Graham, USAF (ret.).

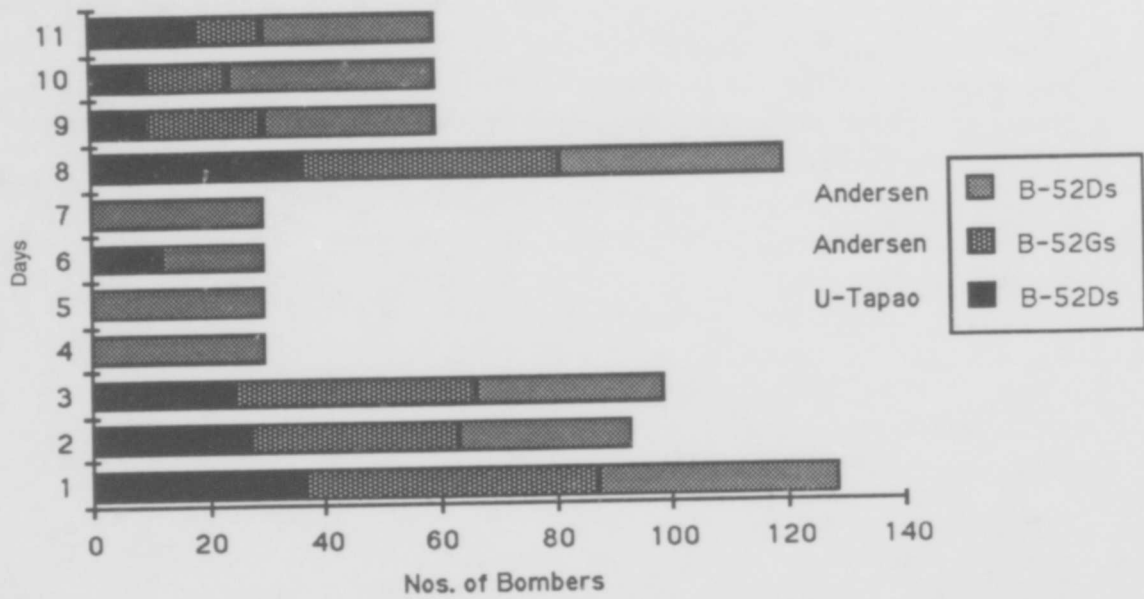


Figure 3.8—Linebacker II Bomber Totals by Day and Base

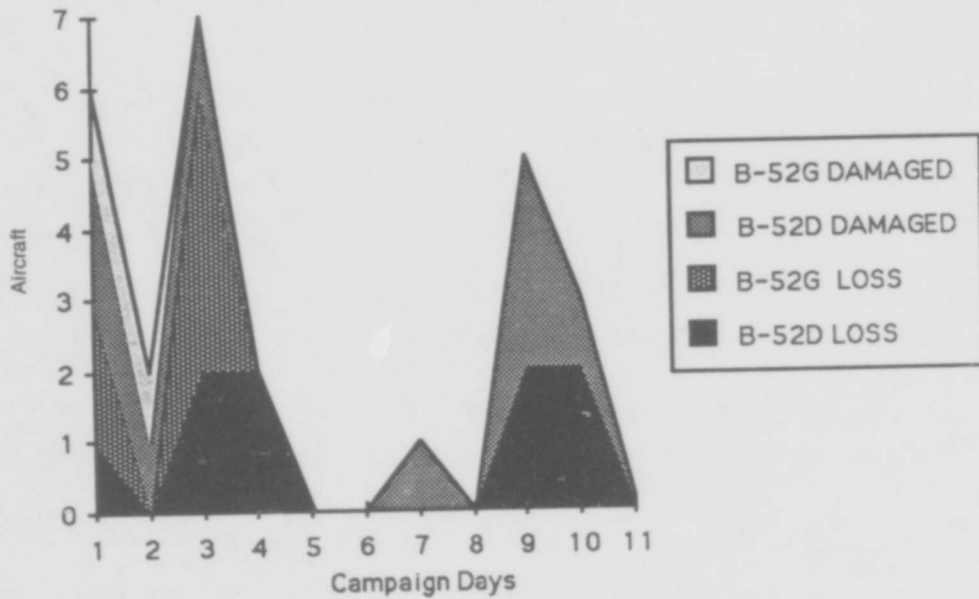


Figure 3.9—B-52 Losses During Linebacker II

**Table 3.3**  
**Linebacker II SA-2 SAM Firings and Effectiveness Against B-52s**

Days	B-52 Sorties	Number of SA-2s Fired at B-52s	B-52s Hit		B-52s Downed		Number of SA-2s for each B-52 Hit	Number of SA-2s for each B-52		Number of SA-2s for each B-52 Downed
			Hit	Downed	Damaged	Downed		Damaged	Downed	
1	129	110	5	3	2	0	22	55	36.6	
2	93	78	2	0	2	0	39	39	-	
3	99	123	7	6	1	6	17.6	123	20.5	
4	30	67	2	2	0	2	33.5	-	33.5	
5	30	76	0	0	0	0	-	-	-	
6	30	1	0	0	0	0	-	-	-	
7	30	14	1	0	1	0	14	14	-	
8	120	200	4	2	2	2	50	100	100	
9	60	76	3	2	1	2	25.3	76	38	
10	60	108	0	0	0	0	-	-	-	
11	60	61	0	0	0	0	-	-	-	
<b>Totals</b>	<b>741</b>	<b>914</b>	<b>24</b>	<b>15<sup>a</sup></b>	<b>9<sup>a</sup></b>	<b>15<sup>a</sup></b>	<b>38.1 average</b>	<b>101.5 average</b>	<b>60.9 average</b>	

SOURCE: HQ, PACAF, *Corona Harvest: USAF Air Operations in Southeast Asia, 1 July 1972 to 15 August 1973, Vol. II.*

<sup>a</sup>Nine of the B-52s lost were D models, and six were G models. Additionally, eight of the B-52s damaged were D models, and one was a G model. Damage was considered by SAC to be minor on six of the nine damaged B-52s.

accordingly; six B-52s were lost and one damaged. Other tactics that affected bomber survivability the first three days included a directive from Omaha that bomb bay doors would be opened two minutes before bomb drop. Not only was the aircraft's radar profile increased, but the 45 to 75 iron bombs carried inside became good radar reflectors. Also, mission planners had the aircraft coming in from the northwest across "Thud Ridge" (named by F-105 crews), dropping their bombs on the targets, and then turning 180 degrees into the wind rather than continuing along the same bomb run. The crews, however, encountered an unexpected 110-knot northwest jet stream across the target that resulted in the aircraft spending an extra ten minutes within the lethal SAM range.<sup>68</sup>

After tactics and routes were changed,<sup>69</sup> losses were much lower. For example, one new tactic to reduce radar reflectivity was—at two minutes before the bomb drop, three aircraft comprising a cell dove two thousand feet together, keeping their bomb bay doors closed until nine seconds before the drop over the target. In addition, the more complicated or innovative attack routes (i.e., many waves from multiple directions) generally resulted in more successful attacks and lower loss rates. These outcomes may have been due partially to NVN confusion but also to the fewer SAMs left at the end of the Linebacker campaign. Figures B.3 through B.19 provide daily ingress/egress routes for the bombers and their support.

As for attrition rates, the prevailing attitude of the crews at Andersen AFB and U-Tapao appeared to be "do anything necessary to get the aircraft off the ground." This attitude was reflective of the importance attached to the missions at the highest levels and percolated down through the ranks. At Andersen, "bag drags" were used to maintain the promised sortie rates. Essentially, a fourth aircraft was readied as a spare in case one of the three aircraft in a cell could not get airborne on schedule. This approach obviously would tend to increase the percentage flown rate. One source notes that one night at Andersen a crew made five successive "bag drags" but was able to join up in flight with its cell.<sup>70</sup> A search of the available documentation, supported by conversations with participants, does not reveal any cases of attrition or accidents caused by combat—in fact, it reveals no accidents at all. If true, this fact can be considered pretty amazing, considering the number of aircraft involved, and has been

<sup>68</sup>Conversation with Maj John Graham, USAF (ret.).

<sup>69</sup>At U-Tapao, about 24 December the electronic warfare officers (EWOs) met with local mission planners to argue that mission tactics had to change because making the 180-degree turn meant the effectiveness of the EW "cones" was degraded and would not protect the aircraft from the SAM threat.

<sup>70</sup>McCarthy and Allison, pp. 22–23.

attributed to the training the crews received for the strategic (i.e., nonconventional) missions for which the B-52 was tasked.<sup>71</sup>

### *Bombing Results*

Severely affecting the NVN logistical and war supporting system, campaign results were most evident in the damage achieved against the major NVN rail and storage facilities. Rail traffic was completely disrupted within ten nautical miles of Hanoi and was seriously degraded on the northeast rail line and the Thai Nguyen rail loop. In addition, associated warehouse complexes were greatly damaged. However, Linebacker I inadvertently had encouraged the North Vietnamese to shift to truck movement and dispersed storage, and so the results were not as damaging to the NVN effort as they might have been had a campaign such as Linebacker II been conducted before Linebacker I.

In a "lessons learned" assessment of weapons effectiveness, it was found that all-weather bombing systems proved effective against area targets, but attempts to use them against small area or point targets were not as effective. Terminally guided weapons proved to be the most effective against hard point targets, but use of these weapons was constrained by weather conditions. To quote a *Corona Harvest* report:

During Linebacker II, B-52s demonstrated their effectiveness against area targets such as storage complexes and large rail yards. Further, tactical aircraft delivering unguided (free fall) bombs under visual conditions proved effective against small or area targets. Laser guided bombs, while extremely accurate, were not available in quantities sufficient to achieve high damage levels against area targets. Guided bombs did, however, prove the only feasible method of destroying hard, point targets such as power plants, radio transmitters, and bridges. Heavy emphasis was, therefore, placed on maximum use of visual deliveries during weather breaks. On the other hand, in an attempt to overcome the impact of bad weather, all-weather tactical or B-52 strikes were sometimes scheduled against hard, point targets. These efforts were relatively fruitless and, in retrospect, should have been applied to area targets. LORAN deliveries were particularly inaccurate and ineffective because the North Vietnamese heartland was at the extreme limits of LORAN's range.<sup>72</sup>

It was concluded that

Until the accuracy of all-weather ordnance delivery systems is dramatically improved, such systems should be employed only against appropriate area

<sup>71</sup>Conversation with Maj John Graham, USAF (ret.).

<sup>72</sup>HQ PACAF, *Corona Harvest: The USAF in Southeast Asia 1970-1973; Lessons Learned and Recommendations: A Compendium*, 16 June 1975, pp. 95-96.

targets, unless overriding psychological objectives dictate otherwise. At the same time, full advantage must be taken of periods of suitable weather to maximize visual delivery of guided and unguided ordnance against appropriate point and small area targets.<sup>73</sup>

It is helpful to put Linebacker II operations in perspective. In January 1973 testimony before the Committee on Appropriations of the House of Representatives, the Chairman of the JCS, Admiral Thomas Moorer, when asked to compare Linebacker II with the bombing campaigns against Germany in World War II and North Korea, provided the following answer:

Three significant factors render any effort to draw parallels between the three operations relatively meaningless.

1. *Bomb loads.*—The ability of World War II and Korean aircraft to carry ordnance was much less than the B-52. B-17, 6000 pounds; B-29, 12,000 pounds; B-26, 3000 pounds; B-52, 50,000 pounds.
2. *Nature of target and ordnance.*—Unlike World War II and Korea, the targets attacked were well defined military targets and every effort was made to use ordnance designed to reduce the risk of civilian casualties. The incendiaries and napalm employed in World War II and Korea on cities as a whole weigh less than iron bombs used with discrimination on the military targets in Southeast Asia. The bombing of Dresden, Germany, during World War II, needs no explanation. Two additional examples from Korea should suffice to make the point.
  - (a) During an 11-hour period on July 11, 1952, 1254 sorties were flown against P'Yongyang by United States, Korean, Australian, and British aircraft. Approximately 2,800,000 pounds of ordnance, including phosphorous and 23,000 gallons of napalm were dropped on the enemy capital. Shortly thereafter, 1686 additional sorties were flown. No worthwhile targets remained.
  - (b) In August of 1952, a steel cantilever bridge across the Han River was targeted. For almost 4 weeks, daily raids with 1000-, 2000-, and 4000-pound bombs on the target, but it still stood.
3. *Air defenses/losses.*—In World War II, air defense missiles were unknown and radar was in its infancy. Hanoi is defended by a very sophisticated and advanced air defense system. We have planned and executed our interdiction campaign to insure maximum survivability for the air crews while making every reasonable effort to minimize civilian casualties. A comparison with one World War II attack may be helpful. Thirty-six B-26's were targeted against the

<sup>73</sup>HQ PACAF, *Corona Harvest: The USAF in Southeast Asia 1970–1973; Lessons Learned and Recommendations: A Compendium*, 16 June 1975, p. 96.

Ahreiler railroad bridge during the Battle of the Bulge—half were lost to enemy fighters alone.<sup>74</sup>

### *Effects on the Prosecution of the War*

The psychological effects of the bombing were not as clear-cut. Reports indicated that in certain areas the population was demoralized and disoriented, but there was no discernible effect on the control of the NVN leadership on the population. The campaign was successful in accomplishing the political purpose of bringing the North Vietnamese back to the negotiating table and thus allowing the United States a face-saving way to exit the war. Furthermore, the campaign illuminated the varied roles for the B-52 bomber when used in roles other than its traditional strategic nuclear mission.

## **Strategic Bombardment and Air Interdiction: Operation Desert Storm**

### *Background*

During an almost 20-year period between Linebacker II and the Persian Gulf War, the transformation of the international environment and the end of the Cold War were beginning. Throughout the period the United States Air Force continued to rely on the venerable B-52 for its contribution to enhancing strategic deterrence while developing and deploying more advanced bombers to take its place. While the B-1B and B-2 have generated controversy over their readiness and costs, the B-52 continues to provide the mainstay of the long-range heavy-bomber fleet. Although observers point out what has become a cliché—that many, if not most, of the pilots flying these aircraft are younger than the aircraft themselves—the “Buff” has continued to undergo extensive modernization in light of evolving and emerging threats. Despite the similarities in external body shape and size, a vast difference exists between the D and F models of Linebacker II and the G (soon to be dismantled) and H models of the current U.S. inventory, not only in terms of weaponry, but also in avionics, defensive systems, and engines. Nevertheless, critics question the enduring role of the B-52 in supporting national interests vis-à-vis other more capable and advanced systems.

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<sup>74</sup>Testimony of Admiral Thomas H. Moorer, Chairman, JCS, on the Bombing of North Vietnam, in *Hearings Before Subcommittees of the Committee on Appropriations, House of Representatives, 93rd Congress, 1st Session, January 9, 1973*, p. 42.

Much has been written about Operation Desert Storm and the effective exploitation of air power during the conflict.<sup>75</sup> Other RAND studies examine the air campaign in detail.<sup>76</sup> This section does not go into depth on the air campaign except to illuminate the role of the B-52 in providing long-range power projection and performing air interdiction against Iraqi forces. To paraphrase the former commander of the Strategic Air Command, General Lee Butler, the B-52s were only marginally successful in the war, being constrained by the lack of appropriate conventional tactics, software, bomb fins, crew training, mission readiness, and precision.<sup>77</sup> Furthermore, their contribution to the air campaign was difficult to distinguish from that of other aircraft, given the numbers of aircraft attacking the same targets and the inadequacies of battle damage assessment.<sup>78</sup> Nevertheless, they met the needs of the air campaign and had an important psychological contribution that postwar POW interviews indicated was as critical as the amount of tonnage dropped on Iraqi armored and artillery forces.

### *Mission Planning, Targeting, and Coordination*

Operational control of the B-52s was turned over by SAC to the Joint Force Air Component Commander (JFACC) resident in Saudi Arabia. This action was a radical departure from previous experience, especially in Vietnam, where SAC maintained control over the bombers. Consequently, the mission planning for use of the bombers was incorporated into the Air Tasking Order (ATO). As related by Brig Gen Patrick P. Caruana, USAF, CENTAF Director of Strategic Forces, "At the height of the air activity, we made B-52s available to CENTCOM to put over the Republican Guard, or any targets for that matter, in Kuwait and Iraq, every three hours."<sup>79</sup>

Mission planning was complicated by the lack of a sufficient number of bases in the theater for the bombers. Three out of four wings were forced to operate outside the theater (in Spain, the United Kingdom, and Diego Garcia), imposing

<sup>75</sup>See, for example, the Gulf War Air Power Survey report (draft, May 1993; final report forthcoming); James P. Coyne, *Airpower in the Gulf*, Arlington, VA, Air Force Association, 1992; Richard P. Hallion, *Storm Over Iraq: Air Power and the Gulf War*, Washington, Smithsonian Institution Press, 1992; and General Accounting Office, *Operation Desert Storm: Limits on the Role and Performance of B-52 Bombers in Conventional Conflicts*, GAO/NSIAD-93-138, Washington, United States General Accounting Office, May 1993.

<sup>76</sup>See Winnefeld, Niblack, and Johnson, *A League of Airmen: U.S. Air Power in the Gulf War*, RAND (forthcoming).

<sup>77</sup>"B-52s were only marginally successful in Gulf war, Gen. Butler says," *Aerospace Daily*, January 28, 1993, p. 155.

<sup>78</sup>GAO, p. 3.

<sup>79</sup>Coyne, p. 80.

mission distances and timelines of 700 to 2900 miles and 14 to 18 hours on the average and limiting combat sortie rates. This distance also imposed a heavy burden on SAC to deploy and sustain the bomber force. The constraints on theater basing were largely caused by political factors—the unwillingness of several potential host nations to accommodate B-52 basing and logistical support until after the air campaign had begun—and the associations the B-52 had with nuclear operations and its role during the Vietnam War.<sup>80</sup>

### *Operations and Tactics*

Operation Desert Shield saw the deployment of 20 B-52Gs<sup>81</sup> to Diego Garcia and Jidda. In addition, missions were flown from bases in the United Kingdom and Spain and, in the case of the first night's attacks, from Barksdale AFB, Louisiana. The latter mission, code named Secret Squirrel, involved seven B-52Gs carrying air-launched cruise missiles (ALCMs) and flying nonstop more than 14,000 miles round trip in 35 hours. This mission set a record as the longest combat mission ever flown by the B-52 or any other aircraft.<sup>82</sup> Thirty-five ALCMs were targeted on Iraq's air defense network. Thirteen other B-52s launched attacks against five Iraqi airfields (As Salman, Glalaysan, Wadi Al Khirr, Mudaysis, and Al Khafi) using mixed weapons loads (UK-1000, CBU-58, and CBU-89).<sup>83</sup>

Low-level attacks (at less than 400 feet altitude at times) were made during the first three nights against strategic targets; after damage was sustained by one aircraft, however, bomb runs were changed to high altitudes (between 30,000 and 40,000 feet) to avoid AAA. After the coalition gained air supremacy, B-52s were no longer confined to night attacks and round-the-clock bombing was instituted. Aircraft based at Jidda flew three- or four-hour missions, sometimes two per day.<sup>84</sup>

Because of the long distances from bases to targets, target assignments were changed for about 25 percent of the missions and then uplinked to the crews

<sup>80</sup>Gulf War Air Power Survey, draft report, Chapter 6, pp. 2-3.

<sup>81</sup>The G model of the B-52 that supported Gulf War operations had two versions: (1) the ALCM B-52G, which carries air-launched cruise missiles, short-range attack missiles, and nuclear gravity bombs, and (2) the conventional B-52G, with conventional munitions such as Have Nap and Harpoon. While a total of about 70,000 pounds of mixed ordnance is advertised, the average total ordnance carried during Desert Storm was about 40,000 pounds. The initial operational capability (IOC) of the B-52G occurred in 1959.

<sup>82</sup>See Department of Defense, *Conduct of the Persian Gulf War: Final Report to Congress*, April 1992, pp. 157, T-26 (hereafter cited as CPGW); Hallion (1992), pp. 171-174.

<sup>83</sup>CPWG, pp. T-25-T-26.

<sup>84</sup>Coyne, p. 80.

enroute. These changes were accommodated but not easily; however, no record exists of any mission failure caused by targeting changes.<sup>85</sup>

Eventually 68 B-52Gs were employed against targets in Kuwait and Iraq. The bombers made 954 sorties to attack strategic targets, such as chemical and nuclear sites, railroad yards and other logistical facilities, Scud missile sites, electrical power production capabilities, and other war-supporting industries. These missions were flown at high altitude and used radar ground mapping for target acquisition.<sup>86</sup> A total of 527 battlefield air interdiction (BAI) sorties were flown against armor, C<sup>3</sup> sites, infantry, minefields, artillery, and other targets. These included attacks on Iraqi assault forces behind front lines in the battle of Khafji beginning on 29 January. Finally, 79 sorties were flown in offensive counterair against airfields and aircraft on the ground using both general purpose and cluster bombs.<sup>87</sup> The total number of missions was 1624, with more than 72,000 weapons dropped and more than 27,500 tons of munitions dropped on area targets in the Kuwait Theater of Operations (KTO).<sup>88</sup>

### *Bomber Attrition and Losses*

No bombers were lost in combat-related incidents. One B-52 suffered minor damage during the first attack of the war; another was apparently hit by AAA or a missile on the third night, but both returned to base safely. Although detailed attrition-related information was not available, apparently one B-52G was lost to noncombat related causes.<sup>89</sup> Various reports stated that the mission capable rate of the bomber remained at greater than 80 percent throughout the war. The B-52s suffered a lack of readiness, especially in terms of prepositioned spares kits,<sup>90</sup> again largely because of the lack of available basing in the theater. Parts from older mothballed and scrapped B-52s stored at the Aircraft Maintenance and Regeneration Center at Davis Monthan AFB, Arizona, helped to relieve maintenance shortages.<sup>91</sup>

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<sup>85</sup>Winnefeld, Niblack, and Johnson, (forthcoming).

<sup>86</sup>CPGW, p. T-26.

<sup>87</sup>CPGW, p. T-26.

<sup>88</sup>CPGW, P. T-26; also Department of the Air Force, *White Paper: Air Force Performance in Desert Storm*, April 1991, pp. 5-6. Other sources differ, but not substantially, with the totals mentioned here; research by RAND's T. M. Parker and Donald Emerson, and former RAND Air Force Fellow Maj Thomas A. Marshall.

<sup>89</sup>Coyne, p. 104.

<sup>90</sup>*Aerospace Daily*, p. 155.

<sup>91</sup>Coyne, p. 133.

## ***Bombing Results***

Successful and accurate bombing was hampered by several factors. SAC crews had been trained and equipped for strategic nuclear missions entailing low-level, autonomous or semiautonomous attacks, primarily to increase bomber survivability, and without fighter support or guidance from command and control aircraft (such as AWACS). In Desert Storm, however, they were employed at high altitudes in mission packages with other aircraft.<sup>92</sup> Consequently, munitions effectiveness dropped, and the aircraft were exposed to the jet stream and other weather-related conditions that affected bomb accuracy. Other factors affecting the bombing results included hardware changes to the bombs themselves, a response to munitions shortages in the theater, and inaccuracies in the avionics software. Nevertheless, the round-the-clock bombing had an important psychological impact in terms of demoralizing the dug-in Iraqi troops.<sup>93</sup> Furthermore, the bombers were instrumental in breaching enemy minefields, a new role that enabled ground forces to surmount barriers and other obstacles. Finally, they apparently provided some measure of deterrence against Scud launches.<sup>94</sup>

## ***Effects on the Prosecution of the War***

While B-52 employment cannot be said to have been critical to the success of Desert Storm—in fact, in hindsight it was considered to have been marginal—the bombers did have important psychological attributes. Reportedly many Iraqi forces surrendered to the coalition forces based on having lived through a B-52 strike or having seen the effects of one on another unit. However, one report concluded that the contribution of the B-52s could not be differentiated from the contribution of other aircraft in the campaign since the bomber was used tactically, its inherent attributes were not exploited as fully as they might have been, and the total tonnage of bombs dropped on targets coupled with BDA limitations inhibited the isolation of B-52 bombing effects from those of other aircraft.<sup>95</sup> But those conclusions should be tempered with the observation that

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<sup>92</sup>The GAO states that “The first time many SAC crews were exposed to airborne warning aircraft or Air Force and Navy tactical fighters was during the war. . . . Because SAC lacked standardized procedures for attacking in formations, crews from different units were reluctant to fly together.” GAO, p. 6.

<sup>93</sup>For examples of the psychological aspects of the B-52 bombing, see Coyne, pp. 88–89.

<sup>94</sup>“They flew along roads we knew were used by the Scud launchers to get to their launch points, especially in the western box, where Scuds had been launched at Israel. The Buffs would drop a bomb or two every fifteen or twenty minutes. All night long. Along with the F-15Es, that kept a lot of movement down.” Maj Gen John A. Corder, CENTAF Director of Operations, quoted in Coyne, p. 56.

<sup>95</sup>GAO, pp. 4–5.

while Desert Storm represented the first use of strategic bombers since the Vietnam War, it probably should not be considered representative of future conflicts in which the bomber may play a key role. The Desert Storm coalition possessed an abundance of air power that may not be available in future conflicts. Constraints in resources likely will force hard choices in the allocation of air assets in future contingencies, perhaps resulting in a more effective exploitation of the bomber.

Now it is time to take a step back and assess the historical campaigns from a broad perspective to identify relevant insights and "lessons learned." From this assessment, we draw some observations for future long-range, conventionally armed bomber operations.

## 4. Lessons Learned

We now return to the original purpose of this study: to gain insights from analysis of past campaigns of the military utility of conventionally armed, heavy bombers and the operational realities of employing bombers. The preceding accounts of past bomber operations suggest a number of lessons learned, which are presented in this section. Several perspectives employed in addressing the individual cases also are used here, namely, mission planning, targeting, and coordination; operations and tactics; bomber availability, attrition and losses; and bombing effectiveness. Some caution is warranted in making direct comparisons over a 50-year time span at a level of operational detail that is very technology- or system-dependent. However, one is struck by the number of fundamental elements and similarities that recur in each case.

### Mission Planning, Targeting, and Coordination

Much of the mission planning and targeting for strategic bombing campaigns such as those addressed in this study rest on key assumptions of what national elements are suitable for striking by a conventionally armed heavy bomber. As noted earlier, the concepts embodied in strategic bombing were formulated and developed by a number of individuals at the Army's Air Corps Tactical School in the early days of air operations. These concepts provided the foundation for the mission planning and targeting conducted during World War II and rested on the belief that targeting the enemy's war-fighting and war-supporting industries would undermine the enemy's capability and will to fight. (More recent terminology calls this targeting the enemy's "centers of gravity."<sup>1</sup>)

Consequently, industrial targets such as electric power, transportation, petroleum and synthetic oil, aluminum and synthetic rubber plants were identified consistently in the various planning documents such as AWPD-1, AWPD-42, and the Combined Bomber Offensive against Germany and Japan.

The targets in the Korean War were similar, primarily because the Japanese had industrialized the Korean peninsula during their occupation. Korea in many

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<sup>1</sup>A key theorist behind this thinking is Col John A. Warden III, USAF. See his *The Air Campaign: Planning for Combat*, Aerospace Education Foundation, Air Force Association, and Pergamon-Brassey's International Defense Publishers, Washington, D.C., 1989, for an exposition of this view of air power.

ways, however, was more like Vietnam in that its industrialization was more limited than (relatively speaking) Germany and Japan. Furthermore, like Vietnam it received extensive support from outside its borders—beyond which the USAF was forbidden to strike. As for North Vietnam, its industrial infrastructure was less directly tied to its will to fight, and strategic targets were less readily identifiable. This factor had a direct bearing on the ability of the United States to effectively curtail the attainment of the North's objectives in South Vietnam. Obviously, the scope and scale of the conflict are important: World War II was a fight for national survival, whereas Korea, Vietnam, and the Gulf War saw much more limited objectives. Therefore, the conflict's scope and objectives have a bearing on the degree to which the importance of negating or totally destroying what one determines as the enemy's "center of gravity" is pursued. In World War II the costs of aircraft and crews associated with the strategic bombing campaign were considered more "acceptable" than those in Korea, Vietnam, and the Gulf as the stakes were so much higher.

Strategic bombing aside, heavy bombers were also used throughout in antisubmarine warfare, countershipping, and aerial mining; close air support; and battlefield air interdiction roles, often quite successfully. These roles came about by design, as a way to showcase aircraft capabilities,<sup>2</sup> and by accident (such as close air support to the Marines at Khe Sanh), willingly or unwillingly (i.e., whether performing that mission took away some measure of capability to perform strategic bombing). Performing these alternative missions necessitated innovative or nontraditional mission planning and targeting as well as coordination with other services and units. Performing those missions also implied a willingness to place Air Force institutional interests aside to accomplish common strategic and tactical objectives. It is important to note that while the Air Force generally attempted to "go it alone" in operations where it believed it had a critical institutional interest, an important contribution of the bomber to the overall war effort was demonstrated in those instances where strategic bombardment doctrine was not applied.<sup>3</sup> Given current trends toward more joint and combined campaigns involving the efforts, systems, and capabilities of all the services and other allies, the Air Force probably will find

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<sup>2</sup>The most well known example is the destruction of several Navy battleships by bombers flown by Billy Mitchell and other Army officers in 1920 and 1923, largely to demonstrate to the Navy the utility of the airplane in coastal defense. For an account of the development of strategic and tactical concepts in the Army air arm before World War II, see Thomas H. Greer, *The Development of Air Doctrine in the Army Air Arm, 1917-1941*, Office of Air Force History, United States Air Force, Washington, D.C., 1985.

<sup>3</sup>One could speculate about the threat posed to Air Force institutional interests by these other roles and missions because, taken to their logical conclusion, they could provide ammunition for the argument for reverting the independent Air Force back to an adjunct of the Army or even the Navy.

fewer opportunities to “go it alone” and increasingly will have to coordinate its mission planning with the other services and allies.

## Operations and Tactics

Throughout the cases we have assessed, operations and tactics consistently have been affected by both aircraft- and crew-related conditions over which the Air Force may have some or complete control and by physical or phenomenological conditions over which the Air Force may have little or no control. Weather falls into the latter category. During World War II (and to a certain extent the Korean War), weather conditions were critical to determining whether a bombing mission would take place or not and whether the outcome would be successful. Furthermore, they had a direct bearing on the ability to identify a target visually and perform a bombing mission, since bombsight technology was less well developed. Weather became less of a factor—albeit still an important one—in Vietnam, since by then the B-52 had the capability to conduct operations in all kinds of weather conditions. Even in the Gulf War, however, weather continued to be a factor in terms of impacting tactical support provided by other aircraft to the B-52s. Other physical conditions that affect bomber operations include geography, winds, and the jet stream, a phenomenon not previously encountered (at least under combat conditions) until the bombing campaign against Japan. Newer technologies such as terrain-following guidance for air-launched missiles and space-based navigation should continue to diminish the impact of geographical and atmospheric conditions in the future.

*Formation Flying:* When one thinks of the strategic bombing campaign against Germany, the picture of hundreds of bombers flying in vast formations comes to mind. The necessity to fly in formations the size of those encountered over the skies of Germany is less obvious today because of advances in electronic warfare, stealth, and other technologies. However, the virtues of flying in some sort of formation may remain valid, depending on the particular aircraft employed and its ability to carry out the mission successfully. The concept of a three- or four-aircraft bomber cell was formulated and exercised in World War II and still is used today in B-52 operations. The lesson learned from this concept is that the principle of mass is still important for both delivery of bombs on the target and defensive firepower against threats. Linebacker II demonstrated that cell integrity was extremely important in defeating threats from MiGs and SAMs. On the other hand, the standardized formations and tactics dictated by Omaha mission planners and employed during the first three days of Linebacker enabled the North Vietnamese to predict the B-52 attacks and to target them with SAMs. Only after the loss of nine aircraft were tactics such as ingress to and egress from

the targets varied in innovative ways. In this case, the strategic nuclear mission procedure that necessitated four minutes of stabilized flight from the initial point to the target for bomb drop was misapplied in conventional operations over North Vietnam. It may have been overtaken by the transition to precision-guided and other "smart" weapons since Vietnam; nevertheless, if the B-52 continues to drop "dumb bombs," then the rationale for this operational procedure will have to be reconsidered (assuming it has not been already). Obviously, the choices made by the commander over the size of a mission, its operational procedures, and its tactics depend on the particular objective and targets he is going against and the threats facing him and his crews. However, he should not let standardized operational procedures based on a nuclear orientation and existing training dictate the conduct of the mission.

*Aircraft Range, Crew Size and Mission Duration.* One attribute of the long-range heavy bomber is its ability to carry out extended duration missions. During World War II, missions to Germany averaged anywhere from eight to ten hours round trip, whereas in the Pacific they were longer. While the record set by the B-52s flying from Barksdale in Desert Storm was the exception, flights supporting the air campaign averaged anywhere from four hours from bases in Saudi Arabia to up to eighteen hours flying from Spain and the United Kingdom. Aircraft range is no longer the critical factor that it was in World War II; now crew endurance in the face of extended ranges may be becoming a key operational concern. The bomber aircraft of World War II and Korea employed approximately ten crew members, but that number has been dropping as increasingly sophisticated technology is deployed aboard newer aircraft such as the B-1B and the B-2. Crew size has dropped to three in the B-1B and to two in the B-2, with computers and other aids replacing the other crew members. One has to be concerned about the capabilities of the crew members in the future to carry out their assigned missions in the face of possible extended range scenarios such as supporting conflicts in Korea or Europe from CONUS bases. Figure 4.1 conceptually illustrates this issue.<sup>4</sup>

One factor that could help mitigate the problem of range and mission duration is the availability of theater basing. As we saw in Linebacker II, the B-52s based in Thailand were employed more easily than those based on Guam. The same observation holds true for Gulf War bomber operations: those aircraft based in Saudi Arabia were more valuable in terms of higher numbers of sorties in

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<sup>4</sup>The average mission duration line from World War II to Korea and on to Vietnam has dipped because missions are being conducted from bases in Japan as well as Korea. In the future, missions in support of a scenario in Korea probably would necessitate employment of bombers from their home bases in the United States.

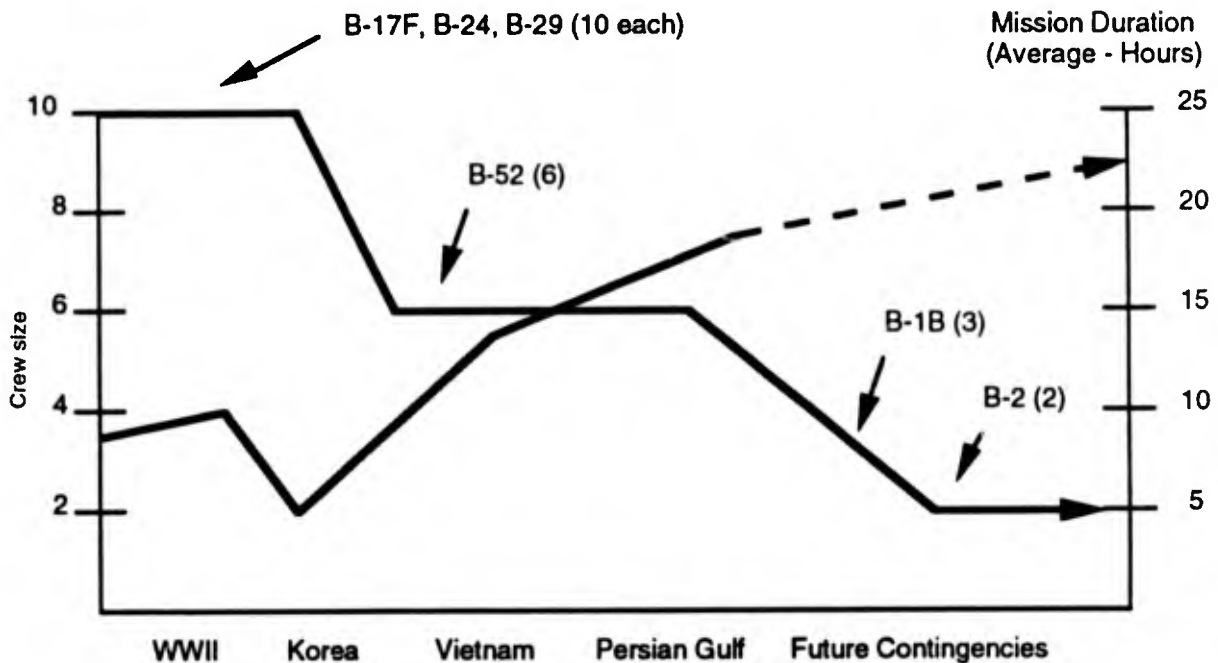


Figure 4.1—Aircraft Crew Size and Average Mission Duration

comparison to those based on Diego Garcia and in Europe and CONUS. While long-range operations have been proven sustainable, they are more demanding in terms of preparation, impacts on crews and aircraft, as well as impacts on supporting capabilities.

Other operational factors such as rules of engagement have become more important to operations and tactics. The “press-on” rules in place in Vietnam and the air defense threat all served to operationally constrain Linebacker II. Since Vietnam collateral damage constraints have become much more prominent, but they now can be satisfied because of increased weapons precision. This change was widely demonstrated during the Gulf War.

## Bomber Availability, Attrition and Losses

Apart from the obvious mechanical aspects, *bomber availability has generally been a function of perceived combat urgency*. The World War II cases are obvious examples of national survival. But the defense of Khe Sanh and the round-the-clock bombing of North Vietnam and Iraq imposed their own senses of combat urgency. In these latter cases, the United States had a surfeit of air power; in Linebacker, however, combat conditions dictated that any and all aircraft be used (i.e., “bag drags” and “press-on” ROEs). In all cases, common sense and combat

necessity dictate the devotion of more assets than mission planning would seem to warrant. This approach must be accounted for when allocating scarce resources or when diverting them from their primary roles for combat-related purposes. In Korea and Vietnam, and probably to a lesser extent in the Gulf War, the impact of pulling a large number of bombers away from their primary mission of nuclear deterrence was a strategic and tactical consideration. But at that point (particularly Vietnam), the strategic objectives of ending the war outweighed the temporary cost of diverting the bombers. By the time of Desert Storm, the United States and the Soviets were in the unprecedented position of being allies in a common effort, so the strategic threat was less acute.

Throughout the historical cases examined, bomber attrition occurred because of mechanical and other noncombat related causes as well as to damage sustained in combat but not serious enough to cause a crash. These reasons probably will remain constant. However, the change over time lies in the costs—military, political, and operational as well as monetary—associated with the platform and the willingness of the political and military leadership to send the aircraft and their crews into situations where they could possibly be lost. Again, this position will largely be dependent on the stakes involved.

But attrition and loss rates can be lowered or minimized through the use of innovative operational measures in conventional bombing, rather than applying traditional, i.e., strategic nuclear, approaches. A fundamental truth is illustrated by Linebacker II: do not string all your bombers along one route, evenly spaced, because if you can count them and predict their course, so can the enemy. Detailed and complicated planning, rather than rigid adherence to traditional approaches, can bring favorable results and enhance crew survivability, but that in turn depends on responsive and innovative training in conventional bombing.

## **Bombing Effectiveness**

Historically, heavy bombers have been more successful in attacking area targets rather than point targets. This success has occurred largely because of the necessity, driven by the threat (flak and fighters in World War II and Korea, SAMs in Vietnam), to bomb from high altitudes, and because of the lack of precision-guided weapons with sufficient accuracy to attack point targets. The introduction of ALCMs and smaller munitions into the conventional bomber inventory, however, will change this situation substantially. Bombers were not used to attack bridges in Linebacker II but were more effective at hitting transportation nodes and power generation facilities. Throughout the cases examined, bomber effectiveness has been affected in part by intelligence,

especially the knowledge and understanding of enemy intent, deception, and reconstitution efforts. The evolving integration of advanced systems for information acquisition and management with air operations (and other military operations) should help to deal with this problem. In general, strategic bombing has not had the expected outcome and benefits that its proponents assigned to it.

## Effects on the Prosecution of the War

To reiterate, the strategic bombardment doctrine was used to guide the bombing of Germany and Japan in World War II, the Linebacker II campaign of the Vietnam War, and to a certain extent, the use of B-52s in Desert Storm. However, each case had a very different outcome. In all cases, strategic objectives were similar but were performed with vastly different levels of effort: the United States was engaged in all-out war against Germany and Japan, while its objectives against Korea, Vietnam, and Iraq were limited to destroying their capability to wage war, not to destroy them as states. However, either because misinterpretations of intelligence or the lack of it, the effects of strategic bombing varied considerably in terms of impact on the leadership and population. In all cases, the national leadership either was not dissuaded from pursuing the war (and in fact followed policies of industrial dispersion), was dissuaded for other reasons outside the actual bombing (such as maritime campaigns conducted in parallel with or before bombing), or was not dissuaded at all from its overriding objectives but, rather, changed its behavior in the near term to gain long-term objectives.

The effects of the bombing on civilian morale also varied: in one case, Germany, having no decisive impact in light of the control the regime imposed on the populace, and in the other case, Japan, having a decisive impact. In the latter case, this outcome may also have been caused by a change in bombing tactics from mass precision to incendiary attacks on cities. The effects of the Korean strategic bombing campaign and the Linebacker II bombing on North Korean and North Vietnamese morale, respectively, were more ambiguous. As for Iraq, while some civilian demoralization may have occurred, it was probably more limited because of the control on external sources of information and the effects of precision targeting. In both of the World War II cases, the bombing of Germany and Japan was a clear precursor to the Allied invasions. In contrast, the Linebacker II campaign was politically motivated and used to instigate a return to the negotiating table by the North Vietnamese; it was never viewed as a necessary prelude to a United States invasion of North Vietnam. For the Gulf War, the hope was that the round-the-clock bombing by B-52s as well as other aircraft would diminish the need for ground operations; however, while ground

operations were initiated, the bombing had the effect of greatly "softening up the opposition."<sup>5</sup>

To sum up, we offer some concluding points. Today the United States is faced with the transformation of the international security environment in ways never conceived by the early air power advocates. This transformation has seen a growing potential for Third World conflicts possibly involving American national interests, a growing uncertainty about the availability of foreign bases for U.S. power projection, and reductions in U.S. defense expenditures and forces in response to perceived changes in the threat. These and other trends point to the potential for increasing reliance on long-range air-breathing weapons platforms to accomplish U.S. national objectives. However, that potential carries far greater political, diplomatic, and financial costs than in previous conflicts, leading to careful consideration of the exploitation of a very valuable resource. Care must be taken not to interpret every previous conflict as unique or to apply the "same old lessons" to every potential future contingency (as in "fighting the last war").

The growth of new aerospace capabilities poses new opportunities for the evolution of the conventionally armed heavy bomber; yet care must be taken not to develop another associated "myth" that may lead to unrealistic expectations of what the bomber can achieve. The United States Air Force should be forewarned that budgetary and other pressures may not allow the advanced bomber to adequately explore and demonstrate its potential, which may directly impact the ability of the United States to pursue its national interests. It remains to be seen within the next few years where the line will fall between these new opportunities and unrealistic expectations.

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<sup>5</sup>General Charles Horner, the JFACC during the Gulf War, makes the point that a lesson of Desert Storm (and earlier campaigns) was that strategic bombing stiffens the will of civilians but breaks the will of enemy military forces.

## Appendix

### A. Summary Data for World War II

Table A.1 includes bomb types used by the Eighth Air Force during World War II. Table A.2 illustrates the percentages, by month, of Eighth Air Force sortie loss rate from August 1942 to December 1944. Figures A.1 and A.2 contain calculations for percentages of bombs expected to hit within 1,000 feet and 2,000 feet of the aiming point for various circular probable errors and average radial errors (based on independent trials).<sup>1</sup>

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<sup>1</sup>Hansell, 1980, Appendix G.

**Table A.1**  
**Principal Bomb Types Used by the Eighth Air Force**

Model	Classification	Approximate Weight (pounds)	Principal Content	Dimensions (inches)
M1	120-pound FRAG		6 × M41	
M6	150-pound IB Cluster		34 × M50A1	
M7	550-pound IB Cluster		128 × M50A1	
M11	500-pound IB Cluster		110 × M50A1	
M12	100-pound IB Cluster		14 × M69	
M17A1	500-pound IB Cluster		110 × M50A1-A3	
M19	500-pound IB Cluster		38 × M69	
M26	500-pound FRAG Cluster		20 × M41	
M30	100-pound GP	100	HE	38.5 × 8.25
M31	300-pound GP	260	HE	48 × 11
M34	2000-pound GP	2050	HE	93 × 23.5
M38A1	100-pound Practice	100	Inert	47.5 × 8
M41	20-pound FRAG	20	HE	22.5 × 3.5
M43	500-pound GP	510	HE	59.25 × 14.25
M44	1000-pound GP	965	HE	69.5 × 19
M47A1	100-pound IB	120	White phosphorus	49 × 8
M47A2	100-pound IB	100	Petroleum gel	49 × 8
M50A1	4-pound IB	3.75	Magnesium	21.25 × 3
M52	2-pound IB	2	Magnesium	18 × 3
M56	4000-pound GP	4201	HE	117.25 × 34.25
M57	250-pound GP	260	HE	48 × 11
M58	500-pound SAP	500		57.75 × 11.75
M59	1000-pound SAP	990		70.5 × 15
M64	500-pound GP	520	RDX	62.5 × 14.25
M65	1000-pound GP	995	RDX	69.5 × 19
M66	2000-pound GP	2050	RDX	93 × 23.5
M69	6-pound IB	6	Petroleum gel	19.5 × 3
M76	500-pound IB	475	Petroleum gel	59.25 × 14.25
M81	260-pound FRAG	260	HE	43.75 × 18
MK1	1600-pound AP	1590	HE	83.5 × 14
MK12	500-pound GP		HE	
MK13	1000-pound SAP		HE	

SOURCE: Roger A. Freeman, *The Mighty Eighth War Manual*, Motorbooks International, Osceola, WI, 1991, p. 228.

Acronyms: FRAG = Fragmentation; AP = Armor Piercing; GP = General Purpose; IB = Incendiary Bomb; SAP = Semi-Armor Piercing

**Table A.2**  
**Eighth Air Force, Percentage Sortie Loss Rate (Heavy Bombers)**

Year	Loss Rate as Percentage of Credit Sorties	
	Bombers	Fighters
August 1942	0%	0.9%
September 1942	1.9%	0%
October 1942	4.5%	0.5%
November 1942	2.9%	0.5%
December 1942	5.8%	0%
Average 1942	3.5%	0.5%
January 1943	7.5%	1.7%
February 1943	8.1%	1.1%
March 1943	3.2%	0.8%
April 1943	7.8%	1.2%
May 1943	5.4%	0.6%
June 1943	6.4%	0.5%
July 1943	5.5%	0.6%
August 1943	6.0%	0.5%
Sept 1943	3.9%	0.5%
Oct 1943	9.2%	0.5%
Nov 1943	3.9%	1.6%
Dec 1943	3.6%	0.8%
Average 1943	5.1%	0.8%
January 1944	3.8%	1.1%
February 1944	3.5%	1.1%
March 1944	3.3%	1.6%
April 1944	3.6%	1.3%
May 1944	2.2%	1.4%
June 1944	1.1%	1.0%
July 1944	1.5%	0.9%
August 1944	1.5%	1.5%
September 1944	2.2%	1.9%
October 1944	1.1%	1.0%
November 1944	2.2%	1.8%
December 1944	1.2%	1.2%
Average 1944	1.9%	1.3%

SOURCE: Williamson Murray, *Strategy for Defeat: The Luftwaffe 1933-1945*, Appendix 4, Air University (ATC), Air University Press, Maxwell AFB, AL, January 1983.

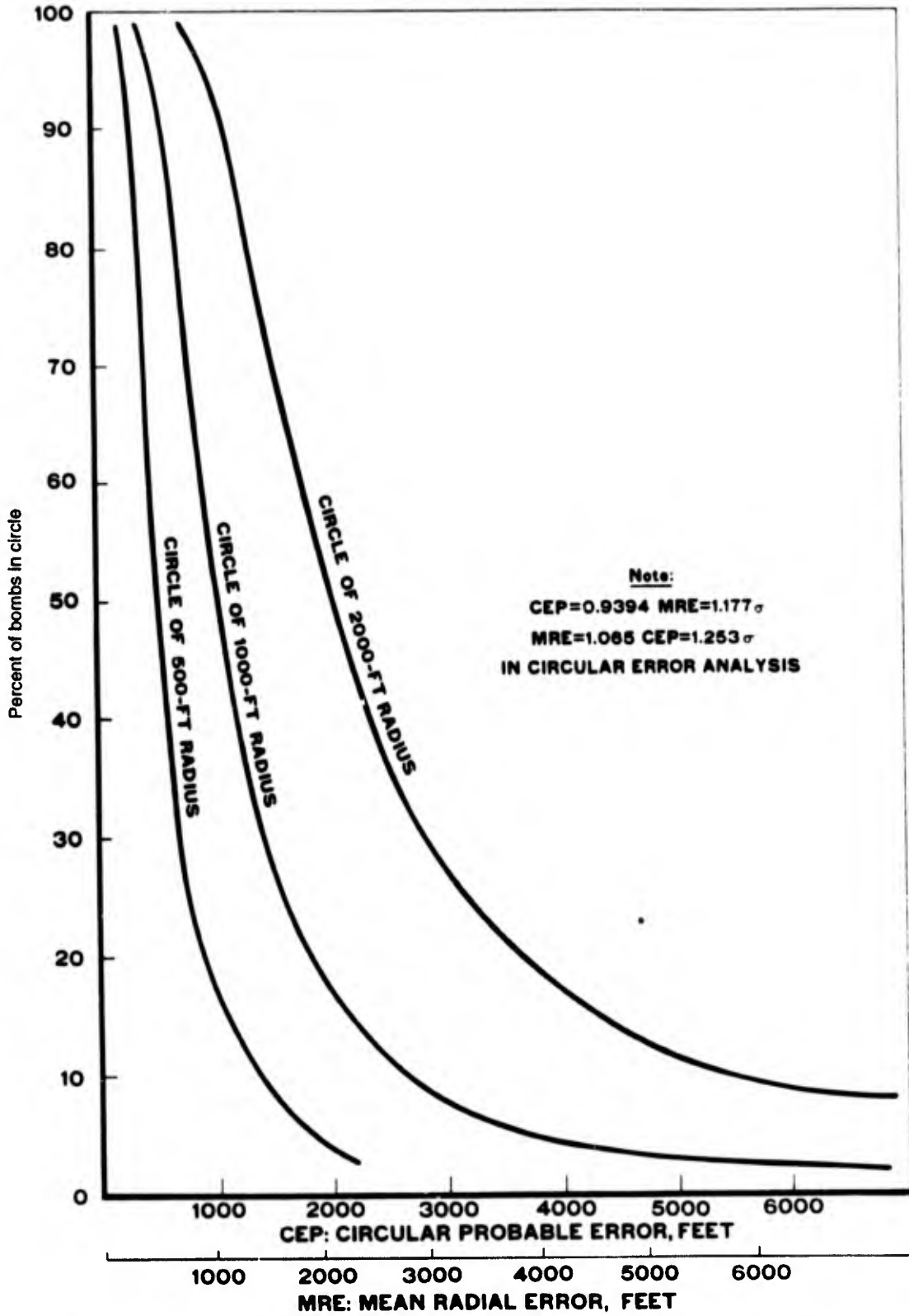


Figure A.1—Conversion Chart—Percent of Bombs in Circle Versus CEP and MRE

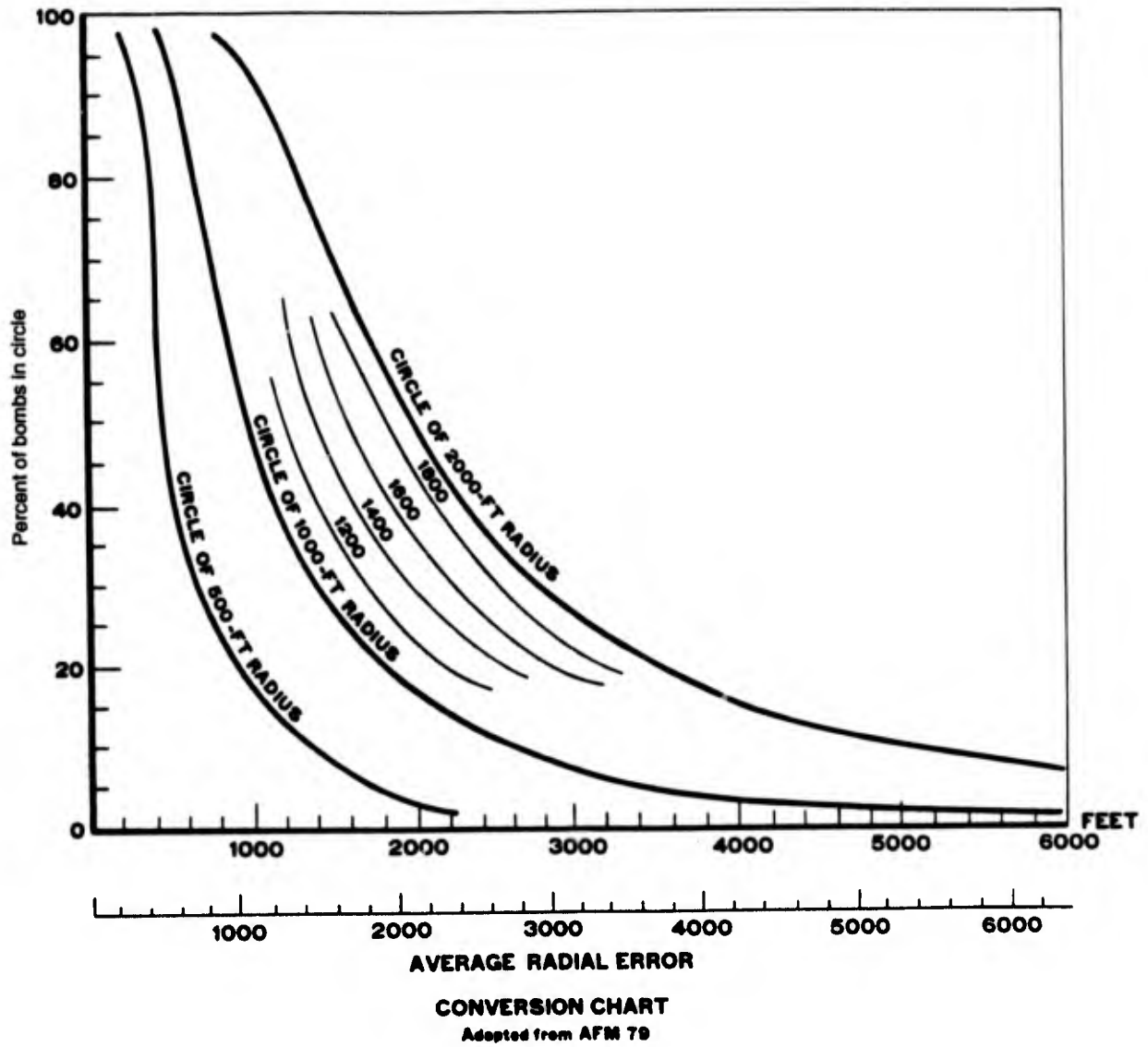


Figure A.2—Conversion Chart—Percent of Bombs in Circle Versus Average Radial Error

## B. Vietnam Summary Data

The Vietnam summary data are given in Tables B.1 and B.2 and Figures B.1 through B.19. Sources for Tables B.1 and B.2 include the *Linebacker II Talking Paper* (December 1972), a daily account of the targets and their locations, air forces employed, and mission descriptions, and various publicly available literature. The source for Figures B.1 and B.2 is the *Linebacker II USAF Bombing Survey* (April 1973). Figures B.3 through B.19 illustrate the ingress/egress routes taken by the bombers and their support aircraft on each day of the campaign and in the first phase for each wave. These figures are included to illustrate and compare the tactics used initially and then changed after the NVN SAMs started taking their toll of aircraft and crews. The figures are from a declassified *Corona Harvest* report.<sup>1</sup>

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<sup>1</sup>Strategic Air Command, *A Strategic Air Command Study on the Effectiveness of Air Power in Southeast Asia*, Vol. I, App. A-Linebacker II-SAC Operations (Project Corona Harvest V, 1 July 1972 to 15 August 1973, declassified).

**Table B.1**  
**Linebacker II Summary Data**

Day	Waves	Bomber Force Size <sup>a</sup>	Distribution	Original Base	Losses <sup>b</sup>
1	1	129			3
		48	21 Ds	U-Tapao	
			12 Ds	Andersen	
	2	30	15 Gs	Andersen	
			12 Ds	Andersen	
			18 Gs	Andersen	
	3	51	21 Ds	U-Tapao	
			12 Ds	Andersen	
			18 Gs	Andersen	
2	1	93			
		21	12 Ds	Andersen	
		9 Gs	Andersen		
	2	36	15 Ds	U-Tapao	
			21 Gs	Andersen	
	3	36	15 Ds	U-Tapao	
			15 Ds	Andersen	
			6 Gs	Andersen	
	3	1	99		
33			15 Ds	U-Tapao	
			15 Ds	Andersen	
			6 Gs	Andersen	
2		27	9 Ds	Andersen	
			18 Gs	Andersen	
3		39	18 Ds	U-Tapao	
			9 Ds	Andersen	
			12 Gs	Andersen	
4		30			2
5	1	30	30 Ds	U-Tapao	
6	1	30	30 Ds	U-Tapao	
6	1		18 Ds	U-Tapao	
			12 Ds	Andersen	
7	1	30	30 Ds	U-Tapao	
8		120			2
	1	18	18 Ds	Andersen	
	2	18	3 Ds	U-Tapao	
			15 Gs	Andersen	
	3	18	18 Ds	Andersen	
	4	18	18 Ds	U-Tapao	
	5	18	18 Ds	U-Tapao	
6	15	15 Gs	Andersen		
7	15	15 Gs	Andersen		

Table B.1—continued

Day	Waves	Bomber Force Size <sup>a</sup>	Distribution	Original Base	Losses <sup>b</sup>
9		60			2
	1	9	9 Gs	Andersen	
	2	12	12 Gs	Andersen	
	3	12	12 Ds	U-Tapao	
	4	12	3 Ds	U-Tapao	
			9 Ds	Andersen	
10	5	12	12 Ds	U-Tapao	
	6	3	3 Ds	U-Tapao	
		60			
	1	12	12 Gs	Andersen	
	2	12	9 Ds	U-Tapao	
			3 Gs	Andersen	
11	3	9	9 Ds	Andersen	
	4	9	9 Ds	U-Tapao	
	5	9	9 Ds	U-Tapao	
	6	9	9 Ds	U-Tapao	
		60			
	1	9	9 Ds	Andersen	
2	9	9 Ds	U-Tapao		
3	9	9 Ds	Andersen		
4	9	9 Gs	Andersen		
5	9	6 Ds	U-Tapao		
		3 Gs	Andersen		
6	15	15 Ds	U-Tapao		

<sup>a</sup>Bombers scheduled, not effective<sup>b</sup>Does not include recovered damaged aircraft

**Table B.2**  
**Linebacker II Targets and Sorties Fraggd**

Target	B-52	F-111	F-4	A-7	Total
<b>Railroad Yards</b>					
Kinh No Railroad Yard/Complex	71				71
Hanoi/Gia Lam Railroad Station/Yard	57				57
Giap Nhi Railroad Yard	17		4	16	37
Haiphong Railroad Siding	27				27
Yen Vien Railroad Yard/Complex	60				60
Thai Nguyen Railroad Yard	36				36
Kep Railroad Yard	12	4	16		32
Trung Quan Railroad Yard	12	2	16		30
Bac Giang Railroad Siding		6	16		22
Duc Noi Railroad Yard	8	1	12		21
Lang Dang Railroad Yard	86				86
Hanoi Railroad Station/Class Yard and Shops			4		4
Viet Tri Railroad Yard		1			1
<b>Total</b>	<b>386</b>	<b>14</b>	<b>68</b>	<b>16</b>	<b>484</b>
<b>Storage Facilities</b>					
Phuc Yen SAM Support	42				42
Duc Noi Storage Area	21				21
Hanoi/Bac Mai Airfield		10			10
Thanh Am/Gia Thuong Complex	21	3			24
Hanoi Storage/Bac Mai	12				12
Van Dien Vehicle Depot	21				21
Hanoi Storage Area/Quinh Loi			8	32	40
Van Dien Vehicle Depot	18				18
Hanoi Port Facility		11			11
Viet Tri Transshipment Point		5	4	24	33
Bac Giang TSP - South		1			1
Trai Ca SAM Support Facility	15		8	32	55
Bac Giang Transshipment Point	30	3			33
Haiphong PPS	18				18
<b>Total</b>	<b>198</b>	<b>33</b>	<b>20</b>	<b>88</b>	<b>339</b>
<b>RADCOM Facilities</b>					
Hanoi RADCOM Transmitter No. 2		6	24	16	46
Hanoi AM Transmitter, Me Tri	36		8		44
Hanoi International RADCOM Transmitter		3	20	10	33
Lang Truoc RADCOM Transmitter		11	28		39
Hanoi International RADCOM Receiver		2	32		34
<b>Total</b>	<b>36</b>	<b>22</b>	<b>112</b>	<b>26</b>	<b>196</b>

Table B.2—continued

Target	B-52	F-111	F-4	A-7	Total
<b>Airfields</b>					
Hoa Lac	6	7	4	24	41
Kep	9	14			23
Phuc Yen	6	10			16
Quang Te	6				6
Yen Bai		11	4	40	55
<b>Total</b>	<b>27</b>	<b>42</b>	<b>8</b>	<b>64</b>	<b>141</b>
<b>SAM Sites</b>					
VN158	3				3
VN004		1			1
VN549	3	1			4
VN234	3				3
VN243	3				3
VN563	2				2
VN537	2				2
VN159		2			2
VN014		1			1
VN186		1			1
VN266	3	1			4
VN660	2				2
VN119		1			1
<b>Total</b>	<b>21</b>	<b>8</b>	<b>0</b>	<b>0</b>	<b>29</b>
<b>Bridges</b>					
Hanoi Railroad/Highway Bridge			4		4
Cao Nung Railroad Bridge		3			3
Lang Lau Railroad Bridge		2			2
<b>Total</b>	<b>0</b>	<b>5</b>	<b>4</b>	<b>0</b>	<b>9</b>

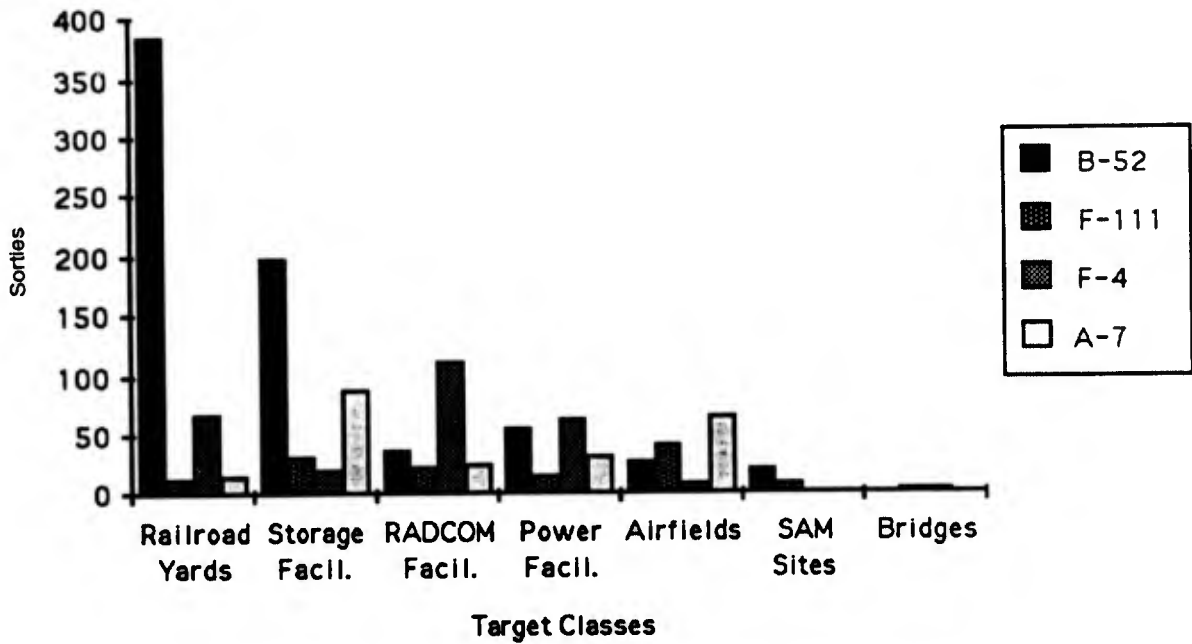


Figure B.1—Types and Numbers of Aircraft Sorties Fraged Against Targets

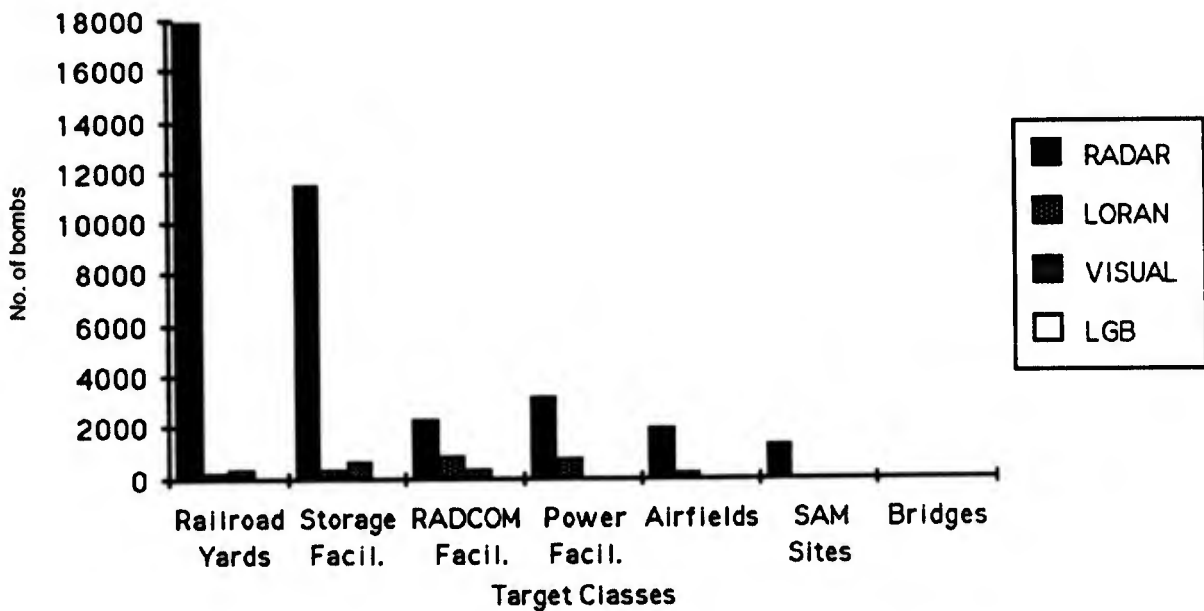


Figure B.2—Types and Totals of Bombs on Target

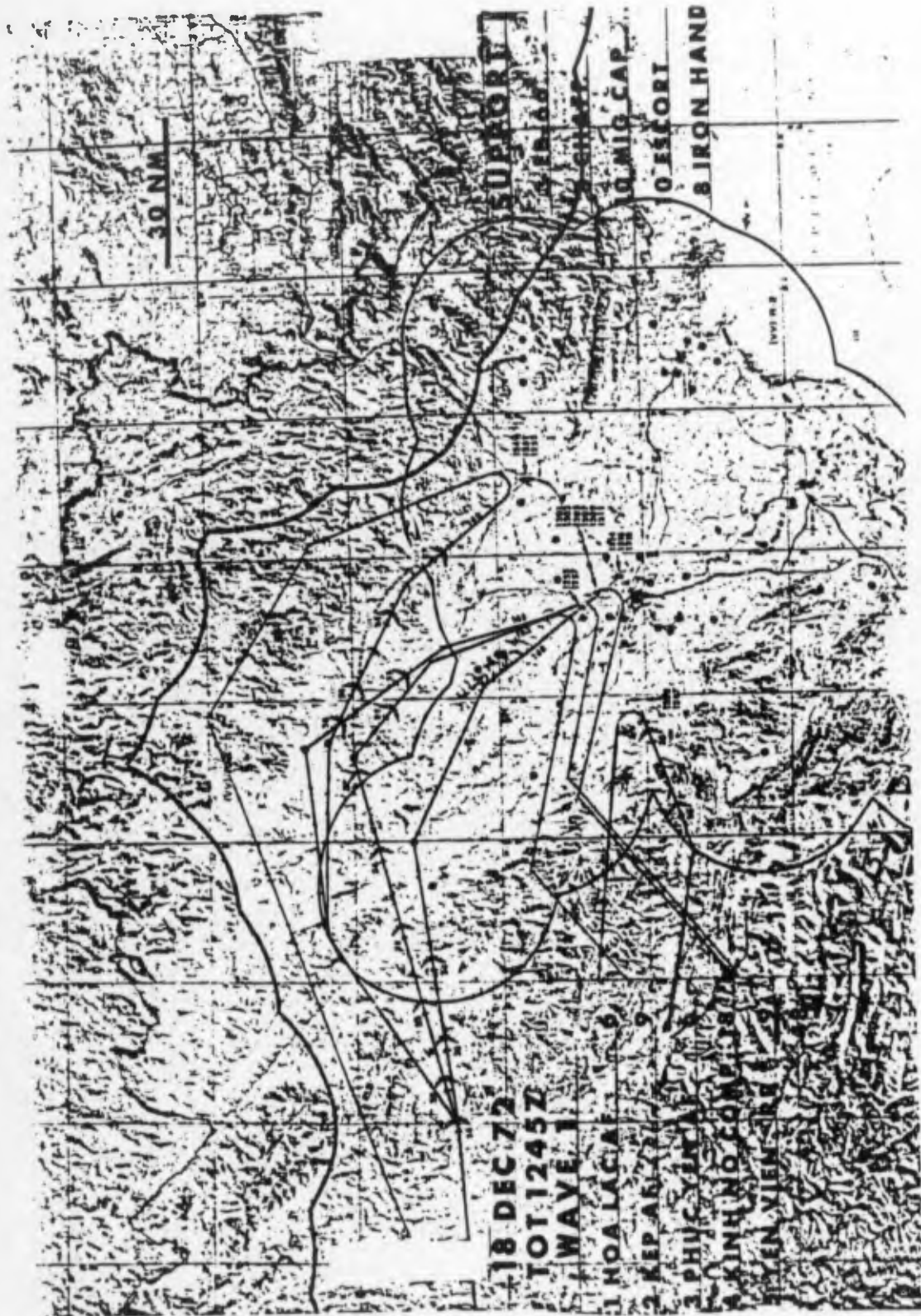


Figure B.3—Wave I, Day 1, 18 December 1972

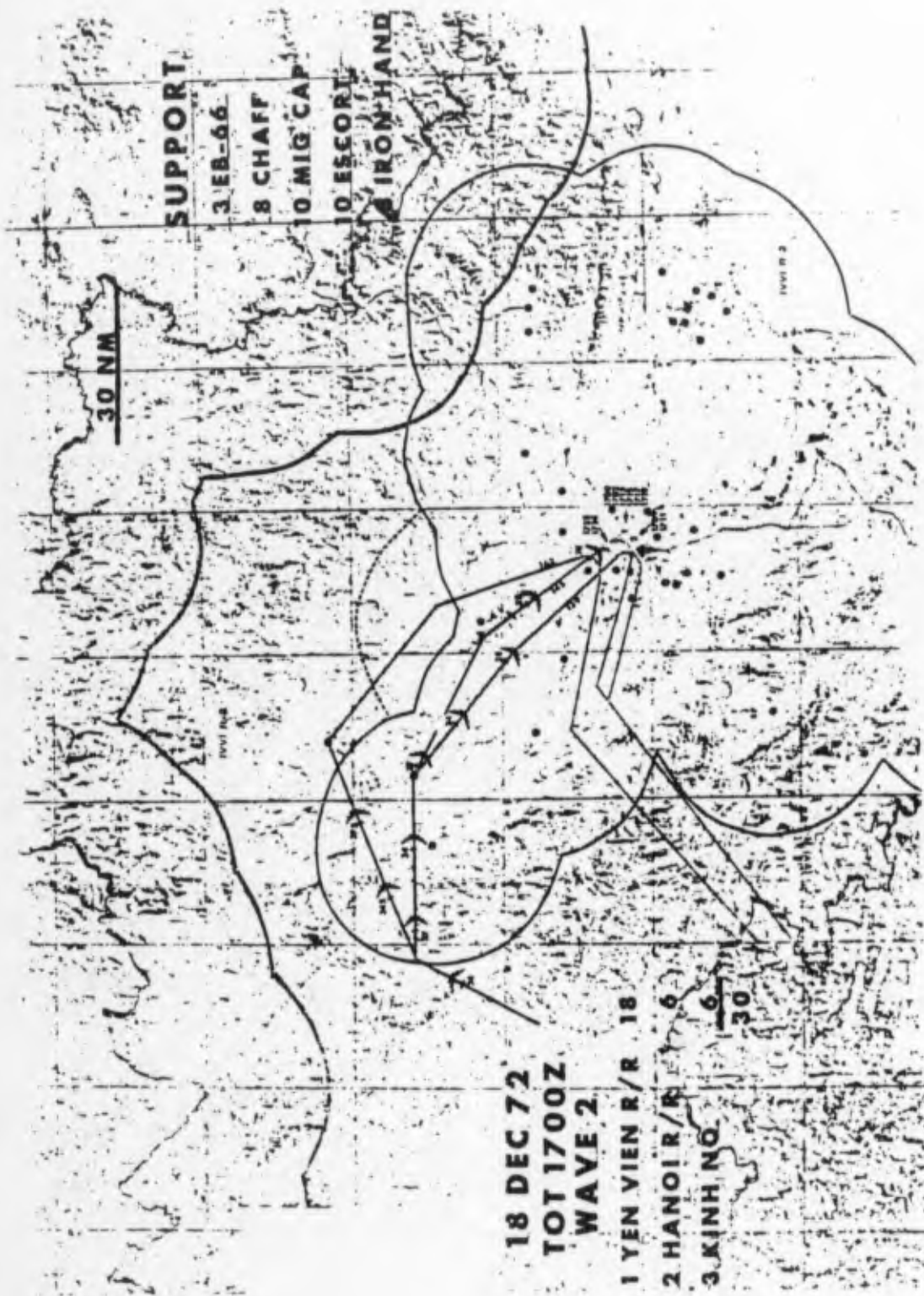


Figure B.4—Wave II, Day 1, 18 December 1972







Figure B.7—Wave II, Day 2, 19 December 1972



Figure B.8—Wave III, Day 2, 19 December 1972



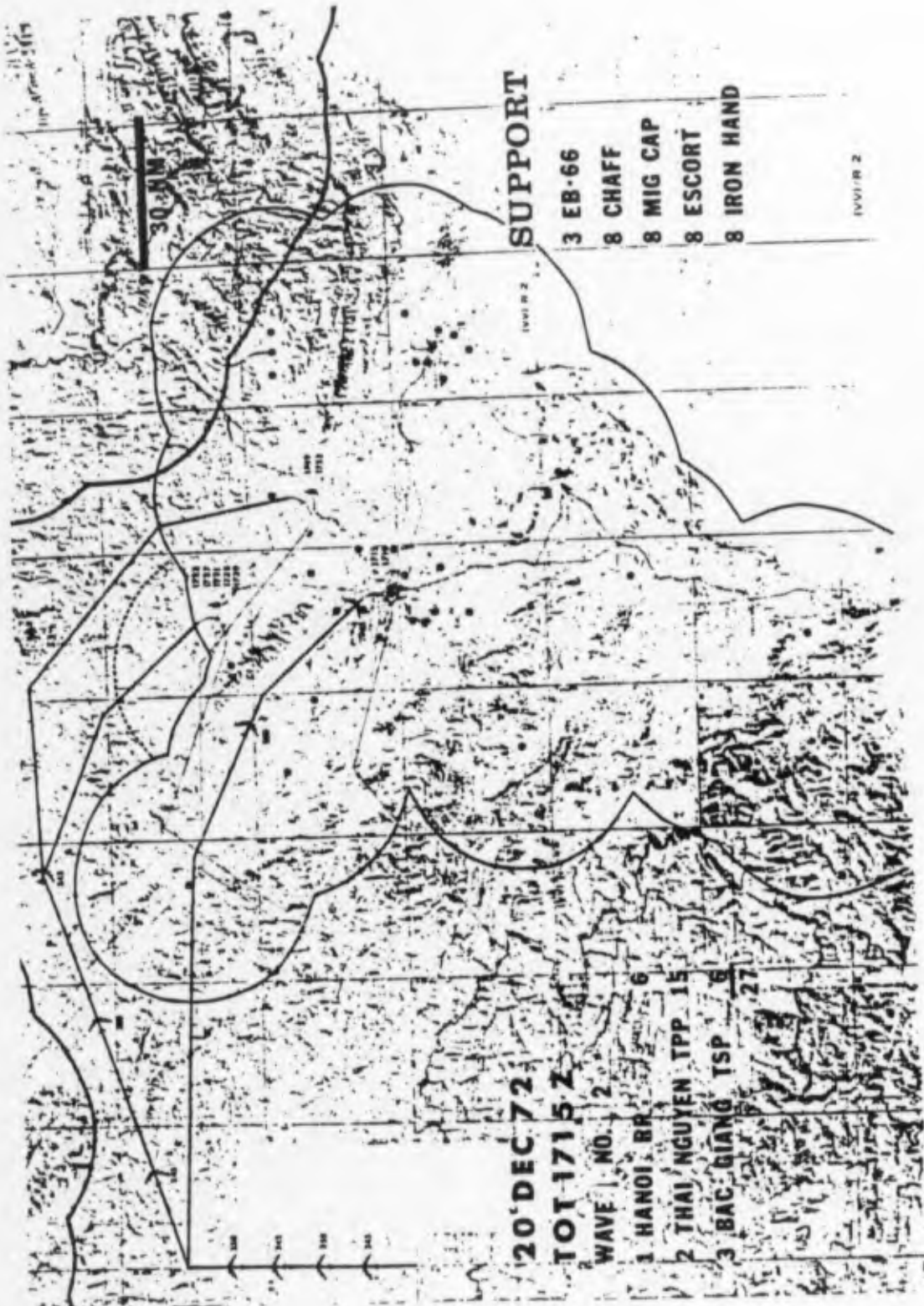


Figure B.10—Wave II, Day 3, 20 December 1972

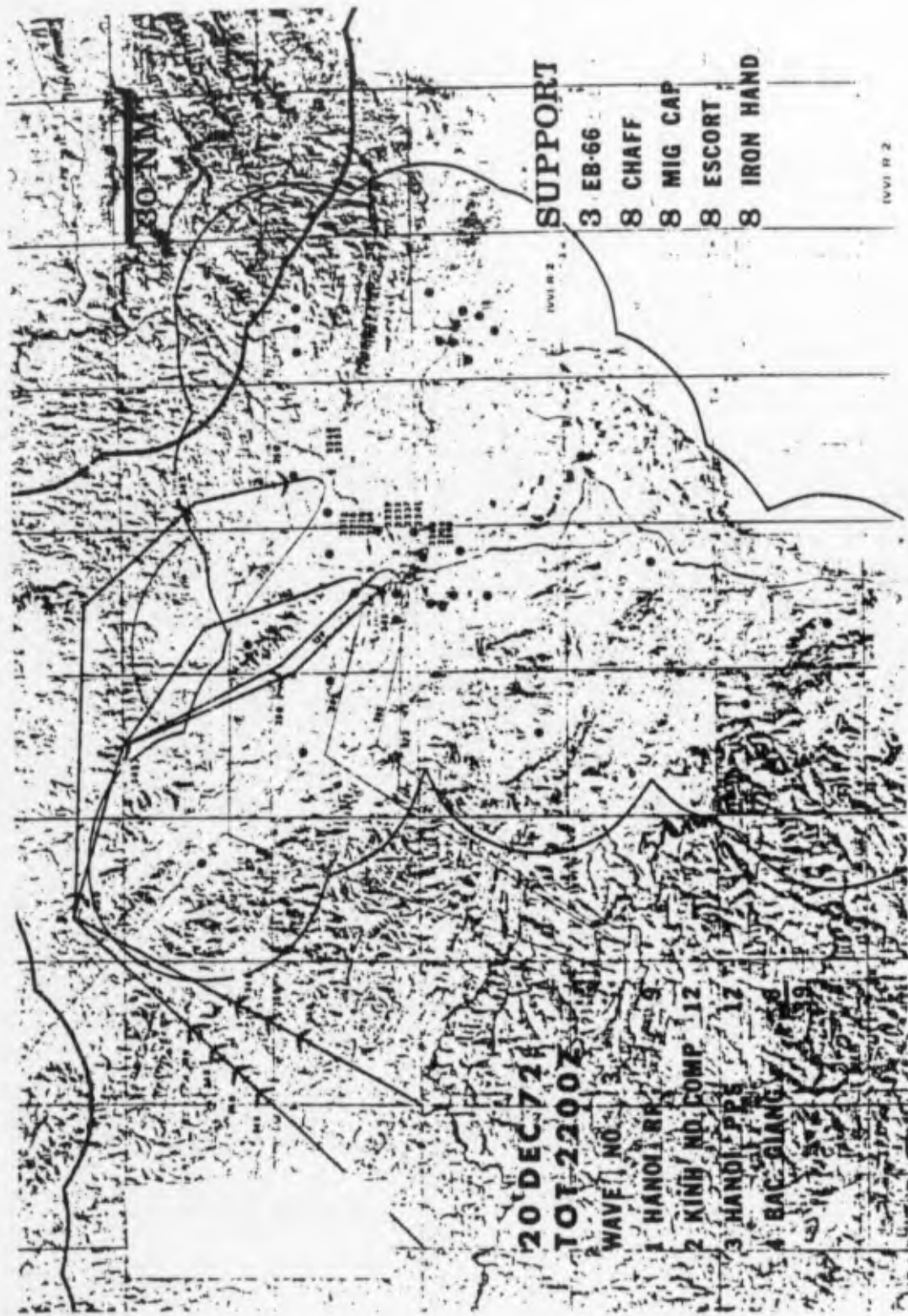


Figure B.11—Wave III, Day 3, 20 December 1972

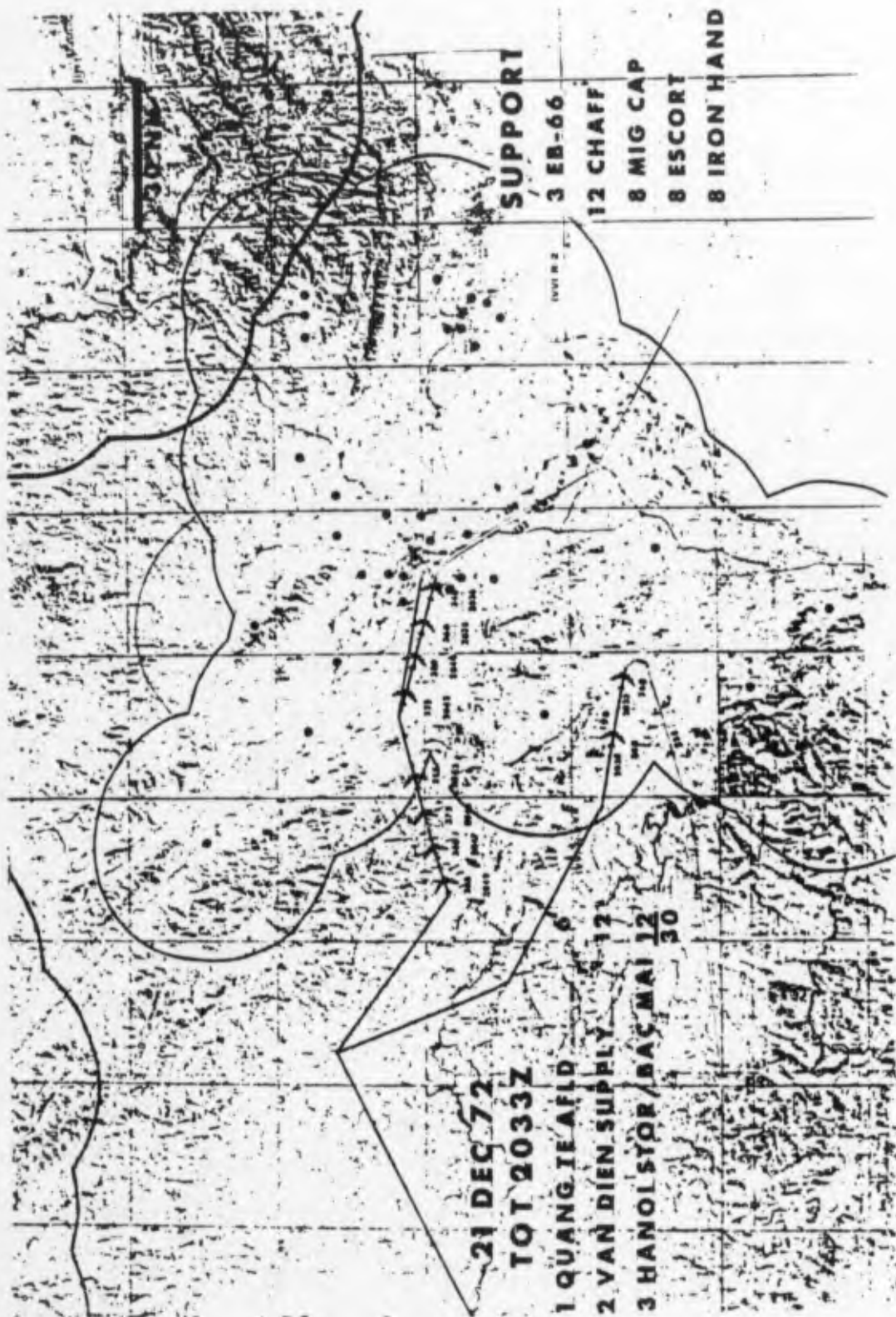


Figure B.12—Day 4, 21 December 1972

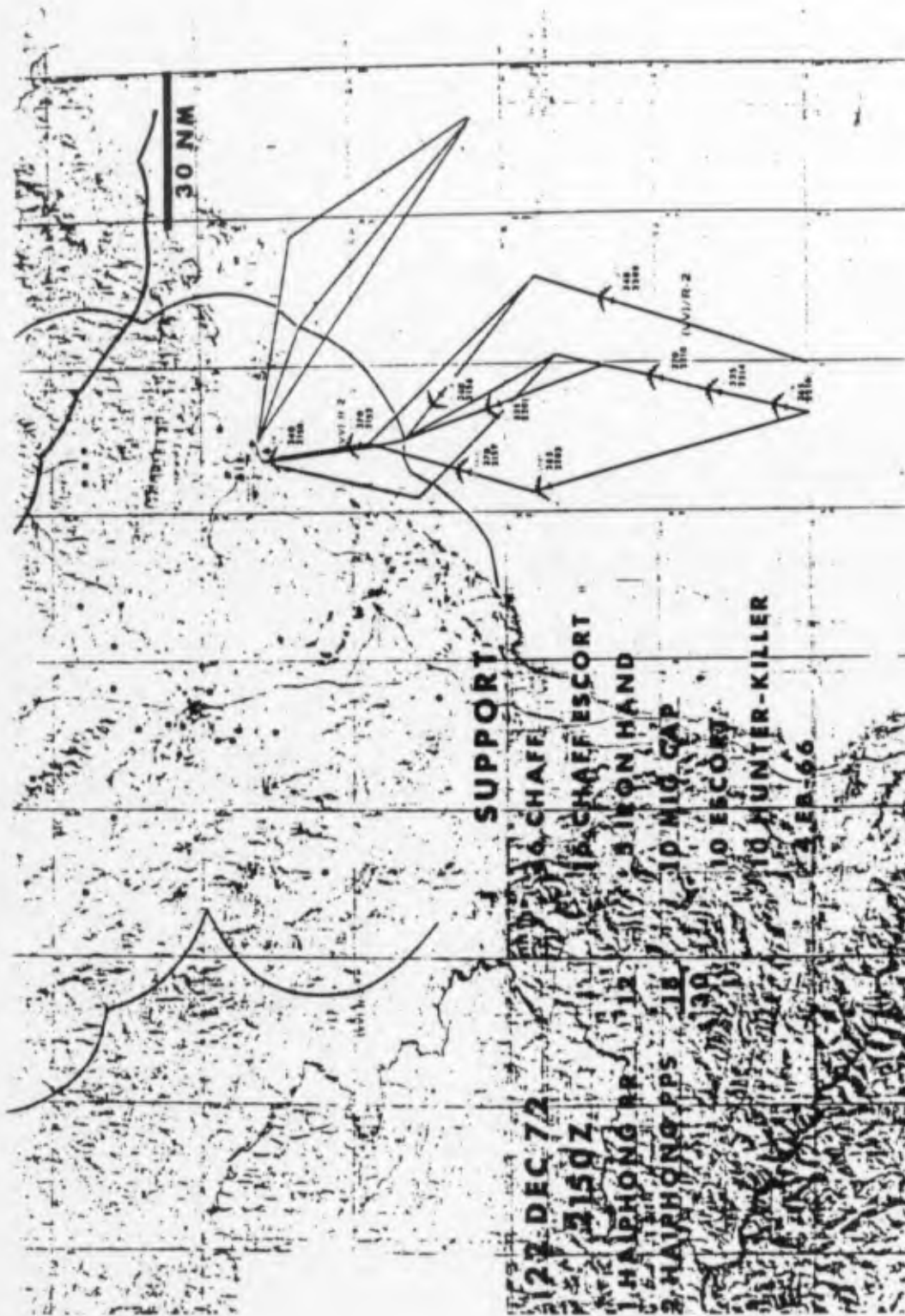


Figure B.13—Day 5, 22 December 1972



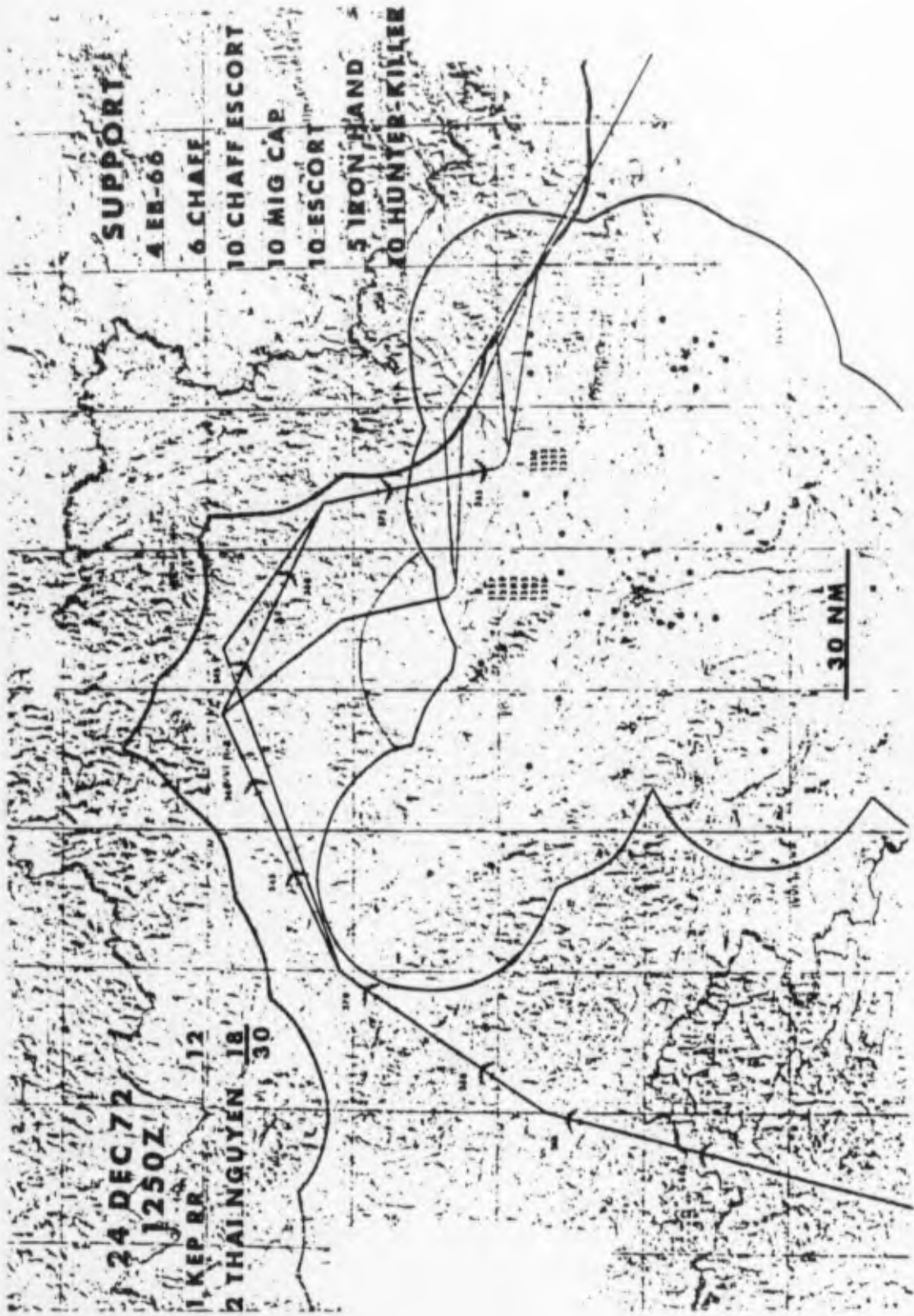


Figure B.15—Day 7, 24 December 1972

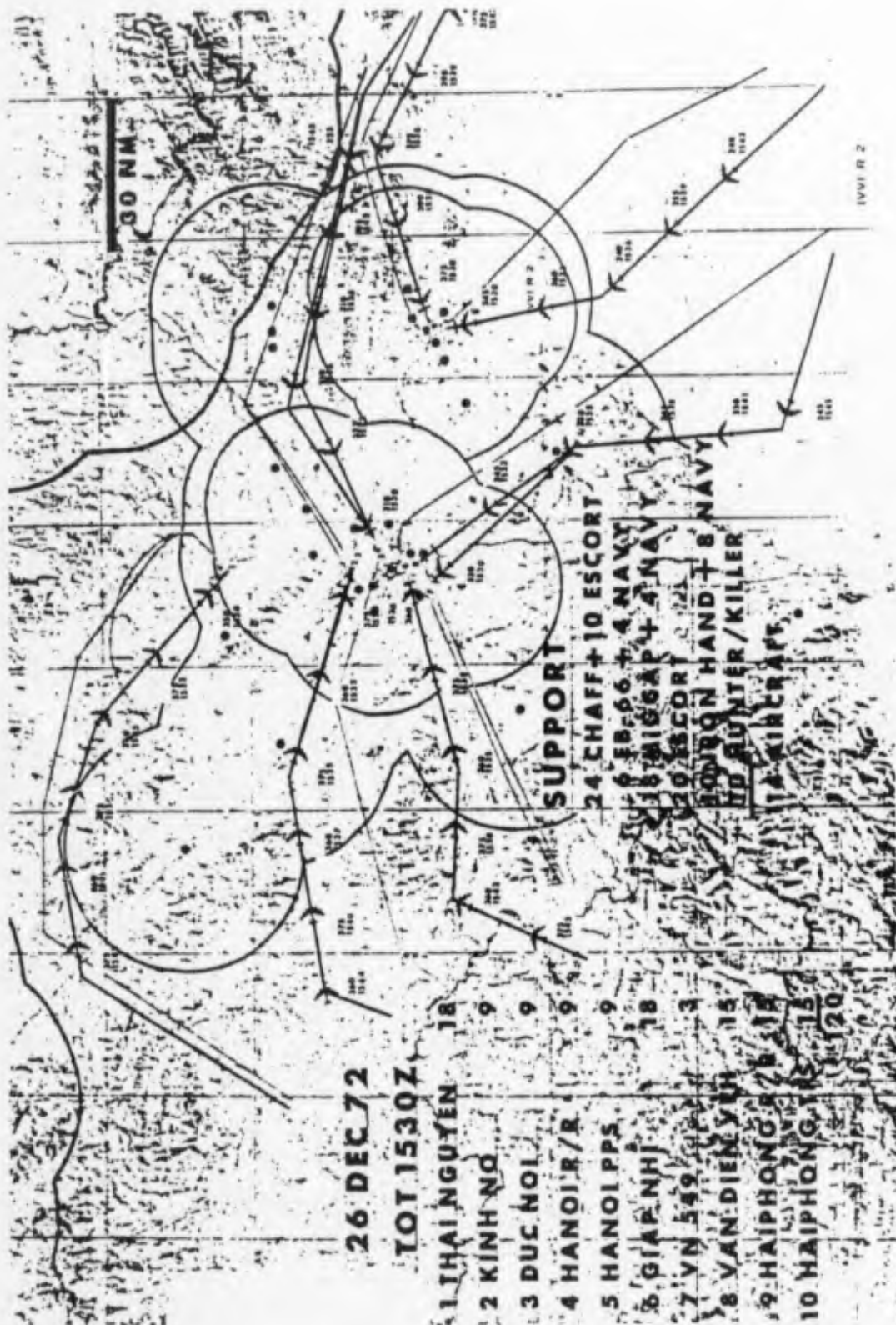


Figure B.16—Day 8, 26 December 1972



Figure B.17—Day 9, 27 December 1972

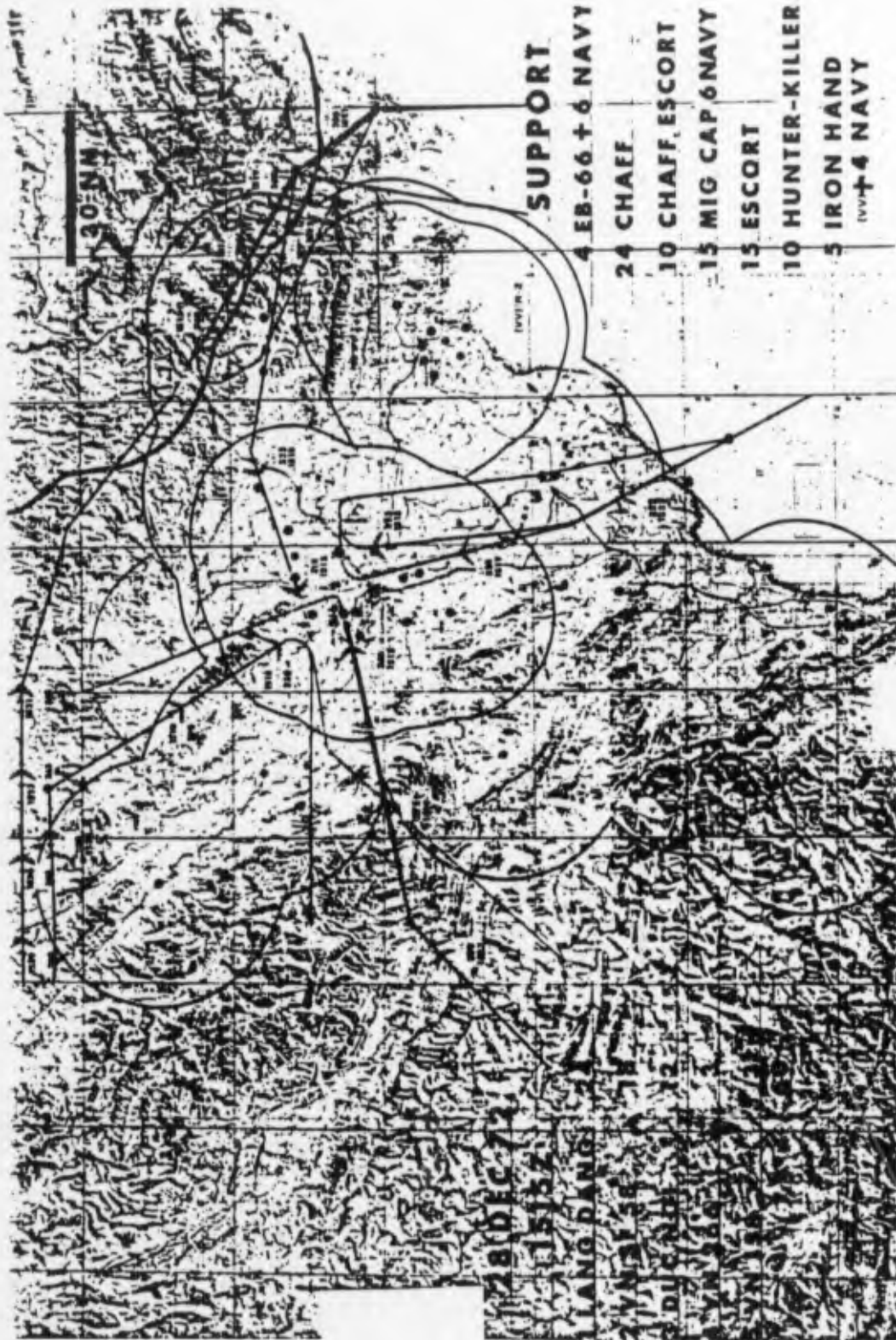


Figure B.18—Day 10, 28 December 1972

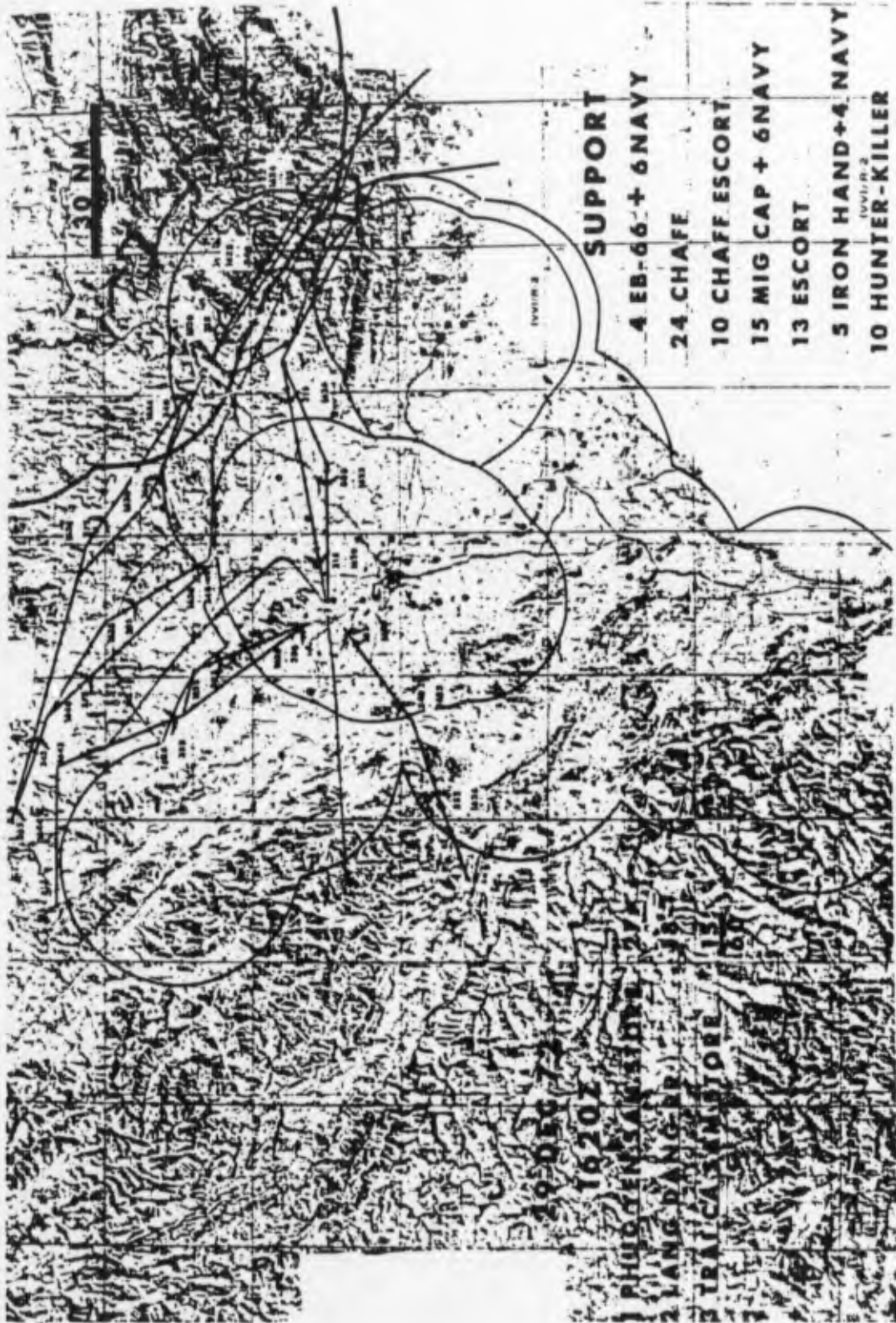


Figure B.19—Day 11, 29 December 1972

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