SCHOOL OF ADVANCED AIRPOWER STUDIES

MINES AWAY!

THE SIGNIFICANCE OF U.S. ARMY AIR FORCES MINELAYING IN WORLD WAR II

By

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Mines Away!

The Significance of U.S. Army Air Forces Minelaying in World War II

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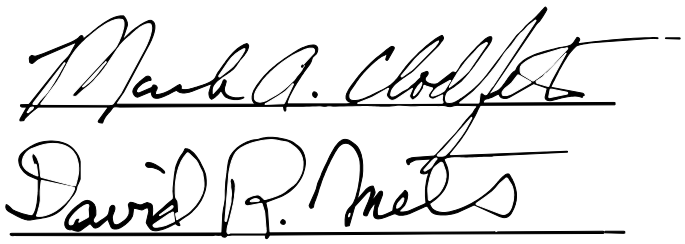

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ABSTRACT

In World War II/s Pacific Theater, the U.S. Army Air Forces (AAF) devoted a small percentage of its long-range capability to aerial minelaying against Japanese warships and commerce. Sea mines--explosive underwater devices that damaged, sank, or deterred ships--were weapons that had difficulty gaining the same acceptance as guns, bombs, and torpedoes. Yet, with time, a small number of aerial mining advocates influenced wartime commanders to ensure the growth of minelaying doctrine, equipment development, and combat experience. Ultimately, aerial minelaying became one of the most successful AAF maritime missions of the war and signalled an important role in sea control for the future U.S. Air Force.

The history of mine warfare spanned more than two hundred years, but as an offensive strategy matured only in the twentieth century, hastened by submarine and aircraft delivery. In World War II, the Luftwaffe was first to lay mines from the air and first to field many of the weapon’s innovations. The Royal Air Force mounted a significant minelaylng effort in Europe and helped the United States advance its mining in the Pacific. Though slow to start, aerial minelaying in Japan’s "Outer Zone" by the air forces of Britain, Australia, and the United States accomplished a worthwhile attrition of Japanese shipping. Finally, in 1945, "Operation Starvation," the aerial mining of Japan’s home islands by AAF B-29s, made a dramatic contribution to the blockade of Japan and mines sunk more ships than allied submarines in the war/s final months.

Minelaying by the AAF had to overcome the absence of doctrine, serious questions of service autonomy, and preconceptions about naval and air force traditional roles. Though this initially unappreciated weapon gained considerable acceptance during the years of World War II, mines were not again dropped from aircraft in combat until the Vietnam War. During the Cold War, the U.S. Air Force gave little effort to its collateral maritime missions until concern grew over containing an expanding Soviet naval threat. Today, Air Force capabilities for aerial minelaying and other naval missions remain an important (though little appreciated) means for projecting long-range air power in support of "Global Reach--Global Power."

BIOGRAPHY

Major John S. Chilstrom (BS, Arizona state University; MS, Abilene Christian University) is a B-1Bpilot. A recent graduate of the inaugural class of the School of Advanced Airpower Studies, he was just assigned to the Operations Directorate at Headquarters USAF/XO, The Pentagon. Also a graduate of Air Command and Staff College, his previous assignment was B-1B instructor pilot at Dyess AFB, Texas. Previous assignments included FB-111A instructor pilot at Pease AFB, New Hampshire, and B-52D/H pilot at Dyess AFB, Texas and Andersen AFB, Guam.

INTRODUCTION

On August 10, 1944, B-29s of the 462nd Bomb Group thundered down the Moesi River only 500 feet above the water, strafed Japanese ships and unleashed a cargo of mines. The "Hellbirds," on the longest mission of the war--4,000 miles and almost nineteen hours--sank three ships, damaged two more and closed the approach to the refinery at Palembang, Sumatra for a month.[1] The Army Air Forces were writing new pages in the history of mine warfare.

In war at sea, mines--explosive underwater devices meant to damage, sink or deter the passage of ships--generally have received scant attention, even within the ranks of the Navy. Known as "weapons that wait," they lacked the dramatic flash of gunfire, or the instant blast from bombs. Yet their little known successes in World War II demonstrated both the tactical and strategic potential of mines. Throughout the war, but particularly in the concentrated campaign known as "Operation Starvation," the significant contribution that long-range air power made to minelaying signalled an important role in sea control for the future U.S. Air Force.

The following work reviews the history of mine warfare and mines, describes their wartime use by Germany and Great Britain, and then focuses on the war in the Pacific. There, the aerial mining of Japan's far-flung empire and home waters proved the value of this little appreciated weapon. Since then, the use of mines in numerous conflicts, including Korea, Vietnam, and the Persian Gulf, further validates the lessons from World War II.

Examining the use of an "unpopular" weapon in the past can offer insights about future weapons employment and how the services work together to employ them. Yet a study of aerial mine laying in World War II is a worthy undertaking for its own sake, to illustrate the surprisingly successful, but largely unheralded, part it played in that conflict.

Map:

Offensive Minelaying Campaign Against Japan

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CHAPTER 1
MINE WARFARE

Theory and History

In the United States Navy, one of the most highly regarded tenets of the naval theorist Alfred Thayer Mahan is that victory in war rests with control of sea communications. [1] One means of disrupting overwater traffic, whether merchant or military, has been through blockade--a mission achievable by using mines. Yet for centuries commanders have shunned mine warfare. Even Mahan regarded mines as weapons of inferior powers and, like Lord St. Vincent of the British Admiralty, "a mode of warfare which those that commanded the seas did not want and which if successful would deprive them of it."[2]

However, World War II naval officers could not afford to ignore that in the American Civil War, the Russo-Japanese War, and World War I, mines sank or damaged more ships than gunfire or torpedoes.3 The greatest number of these mines had been used in "defensive" fields--that is, within friendly waters to safeguard a port or coastal route, while "offensive" mining occurred in enemy controlled waters. Navies could use mines offensively to accomplish strategic goals in a long-term campaign, or to support the temporary objectives of specific tactical operations. In blockading an enemy, mines did far more than sink ships. Ultimately, they shrunk the size of a naval battlefield--producing temporary sea control by disrupting maritime traffic due to the defender's fear of harm to his ships. In addition to sinking, damaging, and delaying shipping, mines caused enemy ships to take circuitous routes and exposed them to attack from other air or sea weapons. The mine threat also preyed on sailors' morale (encouraging the faint-hearted to jump ship) and forced a response with potentially costly countermeasures. [4] Furthermore, a mine was a relatively low cost, twenty-four hour, all-weather threat which required no support, freed navies from the need to perform blockades, and provided minimal risk to friendly forces.[5]

However, economy and unobserved effects fostered the notion of mines as weapons of weakness. Indeed, they originated as defensive devices to protect harbors. In 1585, when the Spanish fleet besieged Antwerp, the Dutch used explosive-laden ships, triggered by a timing mechanism, to disrupt the attack.

Much later an American, David Bushnell, invented what he called the "trigger mine." In 1778 he attempted to float these primitive weapons down the Delaware River so they might explode against British ships in the port of Philadelphia. Though the mines were ineffective, other Americans improved upon his concept. In 1797 Robert Fulton devised a mine with a submarine to deliver it, and in 1843 Samuel Colt successfully detonated a mine using an electrical control over a five-mile cable. The first significant ship casualties from mines occurred during the Crimean and American Civil Wars. In the latter, Confederate mines sank twenty-nine Union ships, compared to only nine Union ships sunk by naval gunfire.6 A generation later, mines played a key role in the Russo-Japanese War of 1904 by claiming sixteen warships.[7]

However, it was not until World War I that mines "found their place on the map."[8] In 1915 Turkish mines in the Dardanelles sunk four capital ships in a single afternoon and prompted the ill-fated Gallipoli landings because allied commanders judged they could not challenge the straits.[9] In that war, belligerents laid over 300,000 mines that damaged or sunk approximately 1,000 ships. During World War II, the United States and United Kingdom together laid over 300,000 mines that sank or damaged 2,665 Axis ships. As an outgrowth of rapid wartime development, mines became more technologically sophisticated, and aircraft became a primary vehicle for delivering them.[l0]

Mines and How They Worked

In the Second World War, ships, submarines, and aircraft all laid mines. Each method of delivery offered certain advantages. Surface ships, which carried large numbers and placed them accurately if no threat appeared, laid two-thirds of the war's mines in defensive fields. Where the water was deep enough, submarines delivered mines with accuracy and the extra advantage of remaining unseen, but at a cost in their ability to carry torpedoes and at some risk from the deployed mines.

Compared with ships and submarines, the airp1ane offered great1y improved speed, range, and f1exibi1ity--it cou1d quick1y p1ace a 1arge number of mines in a hosti1e area. Furthermore, on1y aircraft cou1d safe1y rep1enish an existing minefie1d or reach an enemy's in1and waterway.

The mines themselves were categorized by means of positioning and detonation.[11] Bottom mines

(sometimes ca11ed ground mines) rested on the f1oor of a body of water. Moored mines, bu1ky enough to be delivered on1y by surface ship, had the exp1osive tethered at a specified depth to an anchor on the sea bottom. Drifting mines, floating on or near the surface, were the 1east discriminating type.

Another means of c1assifying mines was by their firing mechanism. One type exp1oded on contact (the only firing method in use before World War II) when a vessel struck the mine and bent a protruding "horn." An additional type was the controlled, or command detonated, variety--usually activated from shore in a defensive field. In World War II, the belligerents developed complex "influence" mines, triggered by a ship's physica1 "disturbance." The first of these were magnetic, actuated by a steel hull; there were also acoustic, which detected propeller or machinery noise; and finally, pressure, which sensed movement through the water. Designers next combined firing methods, making them even more difficult for an enemy to thwart.

Naturally, the invention of the mine produced attempts to counter it. Mines forced a defender to cease movement, take alternate routes (if they existed), or challenge the minefield, with or without clearing it first.[12] Clearing, or "sweeping" a minefield, consisted of removing the mines or simulating a ship's influence and detonating them. The minelayer, to deceive the opponent, could use a small number of different types of mines (known as "jokers") or could significantly vary the types in a "mixed bag" minefield.[13] During the war, mines became sophisticated enough not only to make sweeping difficult, but also determine the size, class, depth, and range of the vessel that triggered them.[14] The minelayer could set mines for delayed activation either by time or number of passes by ships. Mines could also possess self-destructing ("sterilizing") features. [15]

One example of a versatile aerial mine from World War II was the U.S. Navy's Mark 25.[16] The Army Air Forces laid many of these in 1944-45 and almost half of the mines laid in "Operation Starvation," the mining of Japan's home waters, were versions of this mine. Assembled, it weighed approximately 2,000 pounds, which included 1,250 pounds of explosive. The weapon looked much like a bomb with the exception of a half-slant shape to the nose (for improved underwater trajectory) and the parachute pack at the tail. After the mine left the aircraft a static line opened the parachute, which

lessened the shock as the mine entered the water. The Mk. 25 could be dropped from any altitude above 200 feet, at a maximum speed of 230 miles per hour, and used in water depths of 16 to 150 feet. Once the mine settled to the bottom it armed itself according to pre-flight settings and awaited its prey. Different models featured unique firing mechanisms (for magnetic, acoustic, or pressure actuation), clock starters and delays, ship counters, and redundant safety features. The minefield planner could select the Mk. 25 (or a smaller mine, such as the 1,000 pound Mk. 26) with modifications tailored to the specific water depth, type of vessels, traffic frequency, and minesweeping capability.

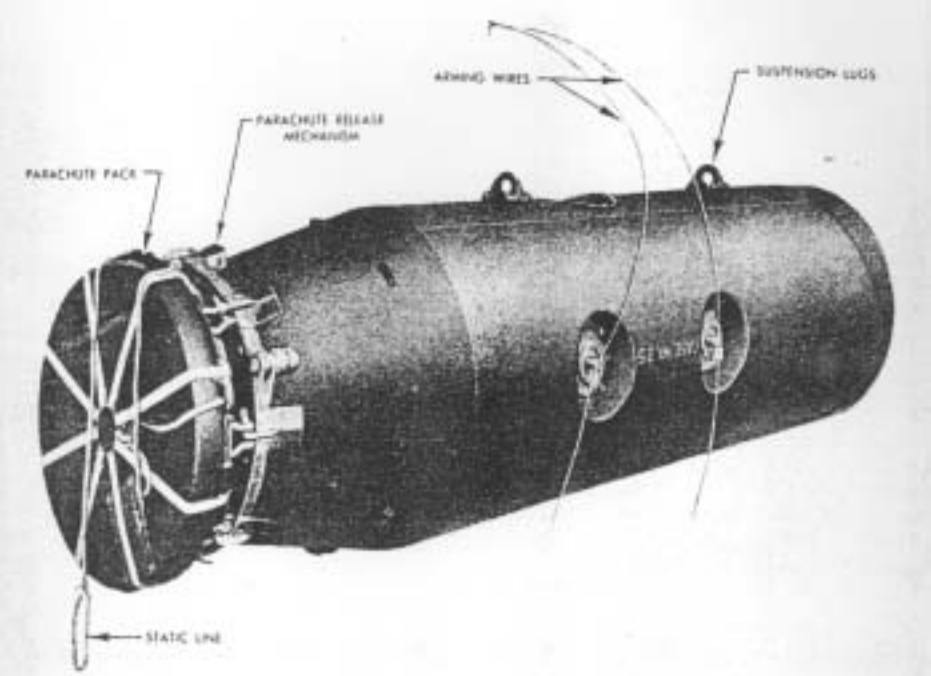

Fig. 2: Mark 25 Mine (From Bottoms Up: Aerial Mines and Modern Warfare, 40.

Mahan did not foresee such sophistication and flexibility. Since in his day command of the sea was as necessary to lay mines as it was for warships to maintain a blockade, mines were most useful for defense--and any seafaring officer knew that was not the proper use of naval power! Not until World War II did submarines and aircraft provide the flexibility to transform mines into effective tools of the offensive.

CHAPTER 2
WORLD WAR II AERIAL MINELAYING IN EUROPE

First Use by Germany

The first recorded aerial minelaylng in combat occurred on November 20. 1939, when nine Heinkel 59 floatplanes flew to the Thames Estuary. Although five turned back due to navigation difficulties, four aircraft laid seven mines that night and thirty-four more in the following two days. However, two of the mines dropped on the third attempt fell in shallow water, enabling the British to recover examples of Germany's "secret" weapon--the magnetic mine. "Britain had captured her biggest prize since the war began." [1]

Though British scientists already had some knowledge of magnetic mine technology, they were caught unprepared, and analysis of the German mines hastened progress on countering the devices. Not only did researchers devise methods to sweep the new mines, but they developed "degaussing" equipment that neutralized the ship/s magnetic field. Nonetheless. The small number of mines laid by aircraft supplemented more extensive mining efforts by German ships and U-boats to spread the hazard to ports and channels those vessels could not reach.

What might have enabled the Germans to blockade England effectively--the combination of submarine interdiction and a minelaying campaign--did not occur partly due to a lack of Navy-Air Force cooperation. The German historian, Cajus Bekker, noted: "One of the most galling topics in the German Navy was its perpetual strife with the Luftwaffe."[2] A longtime point of contention was that Hermann Goering's air force controlled all "strategic" aircraft, including those assigned maritime tasks. The dispute over missions, and the lukewarm nature of air force support for the anti-shipping role, limited the success of the naval war. In February 1940, the Navy's Supreme Commander, Grand Admiral Eric Raeder, reported to Hitler. "The Navy is waging this war to throttle Britain/s lifeline virtually alone!"[3]

Overall, the Germans laid an impressive 223,000 mines in World War II (mostly from surface ships), which sank 576 British vessels.[4] During the war, Germany was probably the most innovative user of mines, yet never had a strategy that allowed them to be decisive. Her armed forces were the first to

lay mines by aircraft; field each new type of influence mine (magnetic, acoustic, pressure, and their combinations); and use ship counters and delayed arming features on mine fuses.

The Royal Air Force Fights Back

The British accomplished almost all allied mining in the European theater. The Royal Air Force (RAF) quickly adapted to the task, and Bomber Command laid 47,307 mines--eighty percent of the total offensive effort.[5] In 1936, an officer in the Air Ministry had been the first to advance the idea of air--dropped magnetic mines. In 1939 that same airman commanded No.5 Group--the sole bomber unit charged with aerial minelaying. He was Arthur T. Harris, who quickly ensured all Bomber Command aircraft could carry mines once he became commander-in-chief in 1942. From the first few mines laid by his Handley Page Hampdens on April 13, 1940, Harris raised the number delivered to just over 1,000 in 1941, and then an average of 1,000 per month for the rest of the war.[6] Though furious prewar bickering had occurred between the Admiralty and Air Ministry over who controlled the mines, wartime relations were notable for their cooperation and efficiency. Actually, the Admiralty welcomed Harris/ mining proposals and the Air Ministry "allowed" them "on the condition that it did not interfere with the bombing of Germany."[7]

For Harris, an airman as devoted to bombing as any; part of the mining mission's appeal was its complementary, strategic effect on Germany. The same bombers that attacked a steel mill in the Ruhr could also lay mines to prevent the iron ore from ever reaching the port of Rotterdam, and they could often do it when foul weather would not allow aircraft to locate their bombing targets.[8] Harris also thought mining would have a greater effect against U-boats than the Royal Navy/s diversion of his bombers to patrol duties. Altogether, he believed that the operations, code-named "Gardening," had "a very considerable Influence on the war at sea without in any way reducing the weight of the [bombing] offensive."[9]

Bomber Command dropped mines along the Norwegian coast, in the Baltic Sea, Heligoland Bight, the Bay of Biscay, and the Mediterranean along the Italian-Sicilian coasts. As an example of tactical support, the RAF laid nearly 4,000 mines between April and June 1944 to prevent interference

with the Normandy landings.[10] The British also mined inland waterways, in particular the Kiel and Koenigsberg Canals, and the Danube River. Thus, the objectives of minelaying varied, from threatening warships and U-boats, to disrupting Germany's ability to import raw materials, transport supplies, or move troops.[11]

One of the greatest frustrations of offensive mining was the difficulty in measuring the results attained. This contributed to an early lack of appreciation for the usefulness of mines. Denis Richards, in his history of the RAF, wrote, "In the minelaying carried out night after night by Bomber Command…there was a weapon at work far more deadly than we real ized."[12] For the effort, (about five percent of Bomber Command sorties), the RAF could eventually claim 762 Axis ships sunk and 196 damaged.[13] (Altogether, British mines in the European theater totalled 260,000--mostly defensive--and ship losses from them numbered 1,590). [14] In addition to sinking ships, the mines disrupted sea communication and blocked transportation on inland waterways. Another effect was tying up a large German minesweeping force, which comprised forty percent of al I German Navy activity by 1945.[15]

For much of the war, the British led the Americans in mine technology, tactics, and employment. Thankfully, mine warfare in the United States profited from a close relationship with the British Commonwealth. As a U.S. Naval Ordnance Laboratory history remarks, these nations gave

> ...the benefit of their experience in degaussing, they furnished samples of German mines and of their own mines, they welcomed U.S. mining experts to their laboratories and sent their own to this country, and in the war in the Pacific, their planes planted more mines than U.S. planes did up until the beginning of the Starvation campaign [from March until August 1945].[16]

CHAPTER 3
MINELAYING IN JAPAN"S "OUTER ZONE" -1942-1945

Early Plans and Capability

Dr. Ellis A. Johnson was a scientist at the Naval Ordnance Laboratory (NOL) in 1941, a naval reserve officer in the Pacific Fleet in 1943, and the chief mining advisor to Major General Curtis LeMay in 1945. He later termed America's early mine policy in World War II as "vague and uncertain" and noted that "what there was of doctrine was completely outdated."[1].Until the well-publicized German use of mines in 1939, the U.S. Navy showed little interest in offensive mining. Still, as of 1942, no single bureau in the Navy existed to plan and direct mine warfare, which was still not appreciated for its offensive potential.

Thus, America entered the war with a small quantity of a single type of air-deliverable mine, and neither the Army nor Navy had plans for them.[2] Some developmental work occurred at the Bureau of Ordnance, but early in the conflict mines did not compete well with other weapons.[3] The Navy's more immediate interest centered on building combat power in the fleet, especially with aircraft carriers and battleships. Minelaying simply did not playa significant role in such plans. What existed within the Office of the Chief of Naval Operations (CNO) in September 1941, was a "Mine Warfare Desk" that planned defensive mining and counter's to enemy laid mines. By January 1943, the CNO made the office an official "section" of his staff and gave it a role in plans and policy. However, before that time, mine warfare suffered from the Navy's "lack of guidance and general lack of interest in mining."[4]

During the first year of war, the armed services developed some mines, but the bulk of the mining effort focused on mine defenses, training, and research. Highly important to future mining operations was the training of personnel--from technicians to aircrews to commanding officer's. At Navy prompting, some Army Air Forces (AAF) aviators attended the Navy Mine Warfare School at Yorktown, Virginia, and the AAF School of Applied Tactics at Orlando, Florida added coursework on mining. The Army later realized the importance of this curriculum. The XXI Bomber Command official history recoded that when orders came to prepare for large scale mining operations, in December"' 1944,

"Key members of the wing and group staffs and command headquarters had already been through the mining course. This training saved many hours of indoctrination in the theatet."[5]

Meanwhile, scientists at the NOL were among the first to use the new field of operations research with wargaming to analyze technical aspects of minefields and evaluate their strategic implications in the war against Japan.[6] In 1941-42 laboratory scientists began developing mines that would not become available until 1944-45.[7] Also, a few mine warfare officers studied in England to learn from the British experience. By 1942, a small nucleus of enthusiasts in the NOL and Navy Department envisioned a strategic mining campaign against Japan's "outer zone"--those territories outside her home islands, Korea, and northern China.[8] Their goal then became to gain fleet and theater commanders/ acceptance of mining as a valid warfighting method.

In February 1943, the Navy assigned three mine warfare officers to the staffs of the commanders in the Southwest Pacific, China-Burma-India (CBI), and Central Pacific theaters. Their "missionary efforts" would determine the emphasis given to mining. Lieutenant Commanders S.L. Quimby, Kenneth Veth, and Ellis Johnson, assigned to the respective staffs of General Douglas MacArthur, Admiral Louis Mountbatten, and Admiral Chester Nimitz, strongly influenced the conduct of mining operations for the rest of the war.[9]

The U.S. Navy's objectives for mining Japan's "outer zone" were broad and simply a statement of offensive mining's potential. Those objectives were:

> To disorganize the enemy maritime supply system, deny him safe ports and shipping routes for the transport of essential war and economic materials, to sink and damage as many of his ships as he would expose to mine risk, and to impose upon him the military and economic burden incident to the establishment and maintenance of a mine defense.[10]

Initial operations were "tolerated (by area commanders) provided they did not seriously interfere with other, more traditional forms of attack. [11] These early efforts served as a test that provided the necessary experience for the Army and Navy in the final year of the war, when both services devoted a great deal of attention to a concentrated mining campaign.

U.S. Navy Submarine and Surface Laid Mines

In August 1942 the Mine Warfare Operational Research Group in the Navy Department recognized Japan's serious vulnerability to attacks on shipping and recommended American submarines begin an "'attrition mining" campaign in Japanese controlled waters.[12] The first such mining occurred on October 16th, when the submarine Thresher placed mines in the Gulf of Siam outside Bangkok. In December, the Triqqer laid mines in straits near Tokyo and immediately witnessed a sinking. During the war, thirty-two submarines positioned 658 mines, creating thirty-three fields in shipping routes along coastal waters. Although range and freedom from detection made them successful minelayers, submarine crews universally preferred a cargo of torpedoes to mines. Minelaying in shallow water made the sub more vulnerable to attack. Moreover, submariners echoed a key complaint that led many commanders to shun the mining effort--they "could never learn until after the war, if then, what damage their mines inflicted; and that was annoying."[13] Submarine-laid mines sank twenty-seven ships and damaged another twenty-seven, producing an enviable kill-ratio of one ship for every twelve mines.[14] Yet, to crews, the unobserved kills did not provide the instant gratification of torpedoes.

In addition to submarines, American surface vessels laid 2,871 mines between August 1942 and May 1944 in seventeen fields around the Solomon Islands. Destroyer minelayers played a key role in stymieing the Japanese reinforcement and evacuation of Guadalcanal, known as the "Tokyo Express," in 1942-43. They sank seven ships (including four destroyers, two submarines, and a merchant ship) and damaged one merchant vessel, all without loss to the minelayers.[15]

Air Operations

The aerial mining of Japan's "outer zone" was a true coalition effort--the Royal Air Force (RAF) flew twenty-two percent of the sorties, the Royal Australian Air Force (RAAF) thirty-eight percent, and U.S. Army and Naval aviation the remainder.[16] The mines they used came from both Britain and the United States. U.S. Navy mine warfare officers, American technicians, and American depots provided the common links between the disparate mining efforts spanning the Indian Ocean to the Central Pacific.

Southwest Pacific mining supported the strategic anti- shipping campaign by hindering the

resupply of Japanese garrisons and the flow of resources to the home islands. In this theater the U.S. Seventh Fleet commander, Vice Admiral Thomas C. Kinkaid, directed the aerial mining almost exclusively conducted by the RAAF.[17] His goal was to cause the most havoc possible given the limited number of mines and aircraft available. This caused him to disperse the effort, never saturating anyone port, but still hurting the Japanese in terms of ships lost and minesweeping required. Kinkaid had no doubts about the value of aerial mining. In a letter to the CNO in July 1944 he claimed, "Aerial mining operations were of the order of 100 times as destructive to the enemy as an equal number of bombing missions against land targets."[18]

The Australians, influenced by Britain's experience with aerial minelaying, proved to be enthusiastic partners.[19] In contrast; the U.S. Fifth Air Force flew only a single B-24 minelaying mission from Port Moresby in June 1943. Comnander Quimby stated that Lieutenant General George Kenney, MacArthur's air commander, "had a poor opinion of mining and was unwilling to spare planes for mining if bombing was at all possible."[20] Such a view typified that of most air commanders unfamiliar with aerial mining. Also, Kenney's light and medium bombers were already successful at destroying ships, and the results of direct aerial attacks were easier to assess than the often unseen effects of mines.

Initially flying from Australian bases at Darwin and Cairns, then from captured island airfields, three squadrons of RAAF PBY-5 Catalinas laid mines in key enemy harbors in the Southwest Pacific. Australian aerial mining began April 22, 1943 when eight aircraft laid sixteen magnetic mines at Kavieng, New Ireland. Those mines, and others at Lorengau in the Admiralty Islands, convinced the Japanese to abandon fleet achorages there after mines sank five ships and damaged seven Others.[21] In August 1943 the RAAF flew over 1,000 miles to attack the headquarters for Japan's Second Southern Expeditionary Fleet at Surabaya. Their mines sank seven ships, and damaged eleven.[22] On this, and other, long-range flights, the Catalinas extended their reach by refueling with U.S. Navy seaplane tenders on the return route. For the next two years the Australians flew missions throughout the Netherlands East Indies, including New Guinea, Halmahera, Celebes, Java, and Borneo. Additionally, in 1944, they laid mines to support amphibious landings in the Carolines, Marshalls, and Philippine

Islands. Ultimately the RAAF extended their reach as far north as the Chinese coast, while still mining all major harbors in the East Indies.

The PBY-5 Catalinas used by the RAAF were amphibious aircraft that provided good results. The aircraft was well suited to minelaying, with long range and a payload of 2,000-4,000 pounds. Out of 1,130 successful sorties that laid 2,498 mines, the Australians lost nine aircraft, a 0.8 percent loss rate. Altogether, the postwar U.S. Strategic Bombing Survey estimated these mines sank 90 ships total ling 250,000 tons, or approximately 40 percent of Japanese losses in the Netherlands East Indies.[23]

From bases in India and Ceylon U.S. Army Air Forces (AAF) B-24s and B-25s of the Tenth Air Force and B-29s of the XX Bomber Command worked together with RAF Liberator bombers of Nos. 222 and 231 Groups to conduct long-range mining missions from Indochina to the Southwest Pacific. Mining proved to be more practical than direct attacks against ships. The aircraft operated at nearly the limit of their range, where it was nearly impossible to loiter and search out individual targets. The first AAF minelaying of the war occurred on February 22, 1943, when ten B-24s laid forty British-supplied mines in the Rangoon River to hamper Japanese troops and supplies headed for Burma. After they added even more mines to the field, few large enemy ships traveled the river for the remainder of the war.[24]

Lieutenant Commander Veth, the senior naval mining officer in the theater, found Admiral Mountbatten and his air commander, Major General George Stratemeyer, to be ready advocates of minelaying. In May the trio persuaded AAF Commanding General "'Hap' Arnold to allow Twentieth Air Force B-29s to begin mining.[25] On August 10, 1944, fourteen B-29s laid their first mines on a mission from China Bay, Ceylon to the refineries at Palembang, Sumatra. The mines sank or damaged seven ships and closed the Moesi River entrance to tankers for a month.26 The XX Bomber Command completed the largest mining effort in the Pacific to date on the night of January 25, 1945, when 76 B-29s took off to lay mines around Singapore, Saigon, and Camranh Bay. Smaller deliveries by the "Superfortresses" reseeded those fields in February and March. During that time, RAF Liberators had already conducted 3,000-mile missions and took responsibility for B-29 target areas when those aircraft left the theater to join the XXI Bomber Command in the Marianas. The coordinated efforts helped

thwart Japanese attempts to reinforce Burma, but not before Stratemeyer, the Commanding General, Eastern Air Command, had become a believer in minelaying. In a letter to "Hap" Arnold in December 1944, he wrote,

> Many persons, both in Army and Naval Air Forces, still think that mining is a means of warfare which should be accomplished by surface craft or submarine, and that when aircraft undertake aerial mining they are actually undertaking so much extra duty for the Navy. This is fundamentally false. In actual fact, the aerial mine is an Air Force weapon with very great potential against the surface Navy and shipping. It may be used defensively or offensively with great flexibllity.27

Commander Veth now called the air force attitude toward mining, "aggressive and enthusiastic...(leading to] one of the most important offensive contributions made by heavy bombers in the (Southeast Asia] area."[28]

Altogether, the British laid 3,450 mines in 697 sorties from July 1944 until July 1945. By mining the harbor at Penang, Malaya, they closed the submarine base used by both the Germans and Japanese. To keep up the pressure against Malayan ports, the RAF laid over 1,000 mines in the first quarter of 1945 alone.[29]

Tenth Air Force B-24s flew from India, while Fourteenth Air Force B-24s and Twentieth Air Force B-29s operated from China to lay mines from the Tonkin Gulf to the Yangtze River from 1943-45. Their purpose was to disrupt convoy traffic and troop resupply by mining such ports as Hong Kong, Canton, Takao, and Shanghai. Missions in China received a high priority to warrant, the long and difficult airlift of mines from Assam, India over the Himalaya "Hump" to a Navy mine detail at Kunming.

Mining along Southeast Asia/s northern coast began on October 18, 1943 when a lone Fourteenth Air Force B-24 dropped three mines in Haiphong Harbor. A single bomber repeated the attack on November 12th. This operation demonstrated the potential of even a small number of mines to destroy and disrupt shipping. The first mines sank a merchant ship, and the second mining another. A ten ship convoy then refused to enter the port, but as it diverted to Hainan Island, Fourteenth Air Force planes attacked it and sank six ships. Afterwards, no traffic larger than junks approached Haiphong.[30]

Elsewhere, at General Claire Chennault/s insistence, Fourteenth Air Force aircraft laid mines along the Yangtze River between October 1944 and May 1945. The effect was to block Japanese steamers from supplying troops fighting inland. The results so pleased Chennault that he remarked, "The aerial mine has done more to stop the Japanese drive north from Canton than any other weapon."[31]

Logistics, early technical problems, and priorities that favored strategic bombing with the China-based B-29s necessarily limited their minelaying. The stateside headquarters of the Twentieth Air Force determined the most important targets to be Manchurian coking coal and synthetic fuel plants. However, a report from the field recommended mining ports as much more economical. The Intelligence Division to U.S. Forces -China Theater, in September 1944, recognized Japan's dependence on such raw material imports. They suggested mining as more profitable than bombing to "dislocate the flow of all the commodities at one time," with the further advantage of permanently sinking the ships necessary for their transport. Their report also stated, "A complete blockade of the ports concerned by aerial mining would virtually paralyze Japanese war industry once the stocks of raw materials inside Japan had been absorbed."[32] However, this study was too late to affect targeting before the Twentieth Air Force removed the B-29s from Chengtu, China. Nonetheless, as recorded in the XX Bomber Command history, "The Command had developed a new potential of the B-29 aircraft--low altitude night mining attack--in a remarkably short time." This capability would soon be exploited in attacks on the Japanese homeland from bases in the Marianas Islands.[33]

In the Central Pacific, the Navy performed most of the minelaying, but Seventh Air Force B-24s from Guam and Saipan supplemented the effort from November 6th through December 18, 1944. Then the 42nd Bomb Squadron flew 101 sorties and laid 227 mines in "Project Mike" to blockade shipping in the Bonin Islands, prior to the invasion of Iwo Jima. When mining began piecemeal, it merely diverted shipping, but after a month of increased efforts, the traffic of large ships dropped from three per day to approximately one a week. Here, the Seventh Air Force pioneered techniques, such as radar navigation and photo evaluation of missions, later used by B-29s mining the home waters of Japan. An AAF Evaluation Board concluded radar was superior to visual minelaying for accuracy, variety in axis of

attack, and the benefit of night and all-weather capability which afforded protection from defenses and usually prevented the enemy from spotting the mines as they were laid.[34]

Minelaying by Naval Aviation

Carrier based TBF Avenger torpedo-bombers occasionally used mines to support anti-shipping air strikes and amphibious landings. When naval aircraft used mines, the objective was a direct, immediate and synergistic effect with another form of attack.[35]

TBFs of Carrier Task Force 58 made the first American carrier-based minelaying at Palau on March 30-31. 1944. They trapped thirty-two ships inside the atoll by mining its passages, allowing aircraft to sink twenty-three with bombs and torpedoes and damage the rest. That action, and additional mining, led the Japanese to abandon Palau as a base.[36] Navy land-based aircraft of Fleet Air Wing One also did limited mining. Their most notable missions were flown from Okinawa in the final months of the war with PB4Y-2 Privateer patrol-bombers operating along the Korean coast. In addition to blocking ports, these mines drove vessels away from the coastline, where over open water the aircraft/s radar could single out ships for direct attack--a mission in which they were highly successful.[37]

Altogether, naval aviation contributed only a small proportion of the minelaying effort, amounting to three percent of al I air-laid mines in the Pacific.[38] One explanation was that naval aircraft operated primarily from carriers and lacked the necessary range and payload for the task. However, such meager participation suggests more than simply a shortage of suitable aircraft. Indeed, the Navy showed a definite lack of enthusiasm for the minelaying mission and a preference for direct attack on ships. For example, in the Southwest Pacific where the Navy had the same PBY-5 aircraft as the Australians, they were not used to lay mines. A post-war history published by the Naval Ordnance Laboratory described the challenge mining advocates had in seeking a commitment to aerial minelaying early in the war:

> The Navy's first minelaying was from surface ships and submarines, a form of warfare with which the Navy had become familiar... On the other hand the Fleet was reluctant to accept the new idea of mines laid by aircraft and was quite willing to have it carried out by other forces. For this reason...the operations were mainly conducted by the Army Air Forces, the Royal Australian Air Force, and the Royal Air Force.[39]

CHAPTER 4
AAF MINELAYING IN JAPAN/S II INNER ZONE" -1945

Planning Operation Starvation

Dr. Ellis A. Johnson first advanced a plan for mining Japan's home waters at the Naval Ordnance Laboratory in May 1942, but failed to generate much support for it. The Navy had decentralized responsibility for mining operations to its area commanders. [1] Johnson, however, persevered. In 1944, as a naval reserve lieutenant commander assigned to Nimitz's staff, he wrote the first detailed plan for mining Japan's inner zone, which gained the admiral's support and became the model for the subsequent operation.[2]

On July 6th Nimitz's staff, including Johnson, briefed the XXI Bomber Command advance echelon when Army Air Forces officers paused in Hawaii enroute to their new base at Saipan.[3] Brigadier General C.E. Thomas, commander of that team, then proposed the mining option to the air staff in Washington, D.C. There the plan met vigorous opposition from Major General Lawrence Kuter, the Assistant Chief of Air Staff for Plans. and Brigadier General Haywood Hansell, the Twentieth Air Force Chief of Staff. After the war, Hansell remembered, "It looked like one more diversion to the local needs of a ground commander, and away from primary industrial targets leading to defeat of the enemy air force."[4]

Meanwhile, General Arnold tasked his Committee of Operations Analysts (COA) for target priorities in the upcoming bombing campaign against Japan from the Marianas. The committee consisted of four civilians and seven military officers--split between Army, Army Air Forces, and Navy. On October 10th the COA provided two separate proposals--one based on defeating Japan by blockade and strategic bombing, and the other on the premise that an invasion must follow a blockade. In the first plan, mining received top priority within a general anti-shipping program. However, the second plan, which assumed an invasion was necessary, gave mining slightly less emphasis. In their words:

> The committee recommends an attack on the aircraft industry and on urban industrial areas and an intensification of the attack on shipping by all available methods, including mining by VLR (Very Long Range, e.g., B-29) aircraft where operationally feasible.[5]

AAF planners, such as Generals Kuter and Lauris Norstad, chose to interpret the phrasing of this paragraph to support their vision of strategic bombing first gaining air superiority, then smashing the Japanese capability and will to resist. In their view, minelaying was a third priority and, given the limited assets then available to XXI Bomber Command mining would, of necessity, be delayed (if accomplished at all).

Yet there was more to this COA report that strongly recommended B-29 mining from the Marianas. In fact, the committee suggested a mining attack in November 1944 and emphasized, "It is possible that the Japanese islands can be blockaded by VLR aircraft through a comprehensive mining program." The recommendations were strong--the door would not be closed on the concept of a strategic mining campaign.[6]

On October 20th, Nimitz addressed the subject in a letter to Admiral King, the Chief of Naval Operations (CNO). On the same date a COA subcommittee of Army and Navy officers proposed a three-phased plan to lay 14,800 mines between December 1944 and August 1945 to defeat Japan through blockade.7 Since this measure required more mines than otherwise planned, the Navy would have to let new contracts for mine components immediately. Kuter was steadfast--"The limited scale of effort available to the Twentieth Air Force should not be diverted from its primary mission [the strategic bombing of industrial targets] until that mission is accomplished."8 In a November 7th letter to Arnold, Admiral Nimitz countered Kuter's reservations.9 Nimitz's proposal recommended a scaled back plan for B-29 aerial mining of Japanese home waters beginning on January 1, 1945 with 150 sorties (600 mines) per month, leading to 1,500 mines per month by the first of April. The pressure was on Arnold to give in.

However, the AAF Chief saw the long-awaited demonstration of the independent capability of air power at stake--he would not condone a diversion of the long-range B-29s from his vision of their primary mission. In his memoir, Global Mission, Arnold wrote that it was essential to mass the maximum number of bombers possible to destroy Japan's war making capability. "MacArthur yelled for the B-29's; Nimitz wanted the B-29's; Stilwell and Mountbatten wanted the B-29's--all for tactical

purposes. " [10]

Thus, on November 28th he compromised by offering support only when the Twentieth Air Force reached full strength, expected by April 1st, and during "weather periods which preclude our normal visual bombing operations so that minimal interference with [the) primary mission will result." On December 22nd he directed Hansell, now commanding the XXI Bomber Command in the Marianas, to prepare his force for a mining effort beginning "about" April at the rate of 150-200 sorties per month.[11] Even then, Arnold's own staff was less than eager. According to the official history of the AAF, Brigadier General Norstad, the new Twentieth Air Force Chief of Staff, "made it clear that the commitment to mining was experimental [and] should not interfere with established bombardment policies."[12]

LeMay and the XXI Bomber Command

On January 20, 1945, General LeMay replaced Hansell as commander of the XXI Bomber Command and quickly supported the mining task. Until then, one of the few AAF leaders to embrace the proposal had been Lieutenant General Millard Harmon, Deputy Commander of the Twentieth Air Force. LeMay agreed with Harmon that "if there had to be mining, the scale of effort proposed in [Arnold's December] directive was inadequate."[13] On January 26th LeMay submitted his own plan to Washington and recommended using an entire bombardment wing, rather than a group, to deliver 1,500 mines per month--the number earlier suggested by Nimitz.

NOTE: Map: Japan and Vicinity (Depicting the mining targets of "Operation Starvation") missing from file.

The aerial mining of Japan's home waters took the name "Operation Starvation"--a program to strangle what remained of Japanese sea lines of communication. Its architects believed mining would so starve both Japan's industry and population that the blockade would fatally weaken the nation's will to continue the war. The plan had three objectives: To prevent raw materials and food from reaching Japan, to prevent the supply and deployment of Japanese military forces, and to disrupt marine transportation within the Inland Sea.[14]

In February the newly arrived 313th Bombardment Wing at Tinian began training B-29 combat crews for the minelaying mission.15 Their aircraft required the AN/APQ-13 radar (for night and bad-weather mine drops over featureless waters>. but needed only minor modification to carry twelve 1,000 pound mines, seven 2,000 pound mines. or a combination. Crews received ground training followed by four to eight practice flights, each with five radar approaches, and alive mine drop on the last.[16]

As the bomb wing planned for the missions, its commanders drew from previous B-29 minelaying experience in the CBI theater and B-24 mining in the Central Pacific.[17] On January 27th LeMay approved the tactics for individual bombers flying at low altitude (between 5.000 and 8.000 feet) to deliver mines at night. This approach eliminated the need for large defensive formations, enhanced accuracy, allowed more mines to be carried, complicated Japanese defensive measures, and provided twelve hours of daylight for search and rescue should the bomber not make it back. The British had been the first to drop mines using radar rather than by visual aiming, but the technique had since been used for minelaylng by AAF B-29s of the 58th Bomb Wing In India, and, most recently, by B-24s of the 11th Bomb Group out of the Marianas.

Preparation for the minelaying campaign was a joint, cooperative effort. The AAF's 313th Bomb Wing carried out the tactical planning and minefield design, and the Navy provided expertise, men, and materiel. The Navy/s mine experts began arriving on Tinian in December 1944. By February 20, 1945 they had established Mine Assembly Depot No.4, which was stocked with 1,500 mines and manned by twelve officers and 171 enlisted men responsible for mine preparation and modification. Lieutenant Commander Ellis Johnson--the man who had nurtured the original campaign plan in 1942 at the Naval Ordnance Laboratory--came from Nimitz's staff to be Chief of the XXI Bomber Command's Aerial Mine Warfare Section. His deputy was AAF Captain George Grossman, former head of the mine curriculum at the School of Applied Tactics and aerial minelaying project officer to the AAF Board at Orlando. Grossman had actually begun training members of the 313th Bomb Wing in November 1944; whi1e the unit was still stateside.[18]

Fig. 4: Aerial Mining from a 313th Bombardment Wing B-29 (USAAF Photo, 1945)

Operation Starvation was a five-phase campaign that began on March 27th. The Joint Target Group, in Washington, D.C. completed target prioritization--a task begun by the COA, which it replaced. Phase one had the dual aim of serving as a strategic blockade while lending tactical support to the Okinawa invasion by hindering Japanese naval reinforcement. The idea was to mine principal shipping bottlenecks heavily and force the enemy to concentrate their limited sweeping capabilities to clear narrow channels. Small areas cleared of mines, once detected by reconnaissance, could be reminded using the continuous efforts of a smaller attacking force. Mining would then spread to progressively distant locations and further tax the minesweepers by using a variety of mine types.[19] Although four missions involved 100 B-29s of the 313th Bomb Wing in a "maximum effort,"most of the

campaign only required the thirty aircraft of its 505th Bomb Group.[20]

Phase one targeted the Shimonoseki Strait, a narrow waterway between Kyushu and Honshu considered "the single most vulnerable point in the enemy's shipping position" since it was crucial to movement on the Inland Sea and along Japan's east coast.[21] It also included mining the naval bases at Kure, Sasebo, and Hiroshima's military port. On the first night of the mining campaign, Brigadier General John H. Davies flew in the lead B-29 to guide his four groups of the 313th Bomb Wing to begin the disruption of Japan's most vital waterways. Between March 27th and April 12th, the wing flew 246 sorties and dropped 2,030 mines on seven separate missions.[22] These results left Ellis Johnson so enthusiastic that he c1aimed the mining thus tar had "completely achieved the mission assigned." He concluded a report on these first missions with a bold proposition:

> It can be stated that the continuation of this minelaying will achieve for the first time by strategic air power, a sea blockade, which previously has been possible only by sea power.[23]

Aerial photography revealed the extent of Japan's unpreparedness and the immediate impact mining had on ship traffic. Mines closed the Shimonoseki Strait for almost two weeks and so restricted Japanese naval traffic that the only passable route was through the Bungo Strait--the Inland Sea's southeastern exit. If ships attempted to sortie through this passage, they faced almost certain detection. Here, on April 6th, a B-29 sighted an Oklnawa-bound task force led by the battleship Yamato. The next day, carrier-based torpedo and dive bombers intercepted and sank Yamato with most of her escorts.

Nimitz was delighted with the beginning of the B-29 mining campaign. On April 7th he sent the following message to LeMay:

Fig. 5: Aerial Photograph of Japan's Shimonoseki Strait (USAAF Photo, 1945)

> The Navy is gratified at being able on Army Day to congratulate the XXI Bomber Command on its outstanding achievement in completing the very effective mining operations reported yesterday. This project, like all your operations to date, has been executed with precision and determination which arouses our admiration. It is a definite contribution toward winning of the war.[24]

Phase two, the" industrial center blockade," consisted of only two missions on May 3rd and 5th, but sent almost 200 aircraft carrying a wide variety of mines against Japanese ports. Its purpose was "to destroy sea-borne commerce between Japan's great industrial zones." Phase two targeted the Shimonoseki Strait, Tokyo, Nagoya, Kobe-Osaka harbors, and snipping lanes of the Inland Sea. The majority of the 1,422 mines used were the 2,000 pound variety, and half were a new, "unsweepable," pressure type.[25] Reconnaissance now showed the number of ships and estimated tonnage passing through the Shimonoseki Strait was only about one-tenth what it had been before the mining campaign. Ship losses mounted, and as shipping diverted to western and northern harbors, the mining campaign

targeted additional ports as well.[26]

Phase three began on May 13th, extending the minefields from Shimonoseki to northwest Honshu and Kyushu. Its purpose was "to blockade the bulk of enemy shipping moving from the Asiatic mainland to Japan." In eight missions, 209 aircraft laid 1,313 mines of disparate varieties, including a small number of "unsweepable" low frequency acoustic mines.[27] The results in May 1945 showed, for the first time, mines sinking more ships per month than submarines--113 in the Shimonoseki Strait alone, which amounted to nine percent of Japan's dwindling merchant fleet.[28]

Phase four intensified the blockade of northwest Honshu and Kyushu, extended it to secondary harbors, and continued to target the Shimonoseki Strait. It began June 7th and for a month consisted of missions flown on alternate nights. During this phase, 404 aircraft, on 14 missions, dropped 3,542 mines.[29]

The fifth and final phase, a "total blockade," lasted from July 9th through August 14th and followed the pattern of the previous month's operations. By now, B-29s sometimes returned to Iwo Jima rather than Tinian to extend their effective range to 3,675 miles and put all of Japan under a nearly complete blockade. The bombers maintained the minefields in the Shimonoseki Strait, the ports of northwest Honshu and Kyushu, and also Korean harbors at Pusan, Masan, Wonsan. Hungnam. and Chongjin. During this period the minelaying B-29s also dropped four and a half mill ion psychological warfare pamphlets emphasizing to the Japanese that their deteriorating food situation was one effect of the mine blockade. In the last phase, 4-74 aircraft on fifteen missions laid 3,746 mines.[30]

The minelaying continued until the final day of the war. Before the campaign ended, Admiral Nimitz once again emphasized his appreciation to the Army Air Forces. On August 2nd he stated:

> The continued effectiveness of Twentieth Air Force mining is a source of gratification. The planning, operational, and technical execution of aircraft mining on a scale never before attained has accomplished phenomenal results and is a credit to all concerned.[31]

CHAPTER 5
PLAN AND REALITY -THE EFFECTIVENESS OF AAF MINELAYING

Plans and Opportunities

From the outset of World War II, the offensive minelaying mission suffered from a lack of pre-war interest and from the absence of a single service organization to exploit its potential. The U.S. Strategic Bombing Survey concluded, "Mines, perhaps more than any other weapon of equa1 accomplishment, were orphans during the war. "[1] As a consequence, no coordinated theater-wide strategy existed for their use. The success enjoyed by the mining campaigns was a testimony to strong efforts by a small number of be1ievers such as Ellis Johnson and Kenneth Veth, who ultimately persuaded admirals and generals that aerial mining would be effective. In spite of deficiencies in planning for the mining campaign, the Allies industria1 might produce an overwhelming number of mines that swamped Japan's fragile lines of communication.

Early in the war, American planners recognized Japan's reliance on shipping and its vulnerability to blockade. An October 1943 report by the Committee of Operations Analysts (COA) estimated that Japan imported 80 percent of all oil supplies, 88 percent of all iron, 24 percent of all coal (including 90 percent of coking coal), and 30 percent of all food by sea.[2] The committee also accurately predicted 75 percent of all domestic Japanese transportation used coastal and inland waterways--most of which was out of reach to American submarines due to defensive minefields or shallow depth. Additionally, Japan's armed forces had the burden of a supply line 3,000 miles long and were equally dependent on exposed sea lines of communication. In the words of the Transportation Division's report to the Strategic Bombing Survey, "No major power in the world was more dependent upon ocean shipping than Japan."[3]

To satisfy ever-increasing demands, Japan entered the war with 6,000,000 tons of shipping and seized another 823,000 tons in early conquests. However, its military failed to use this sealift capacity efficiently and also to plan shipbuilding for a lengthy conflict. From 1942 on, the Allies sank ships faster than Japan could replace them. [4] By the start of "Operation Starvation," shipping had been reduced to only 2,000,000 tons. Significantly, traffic between inland seaports became even more critical as industry

dispersed due to Twentieth Air Force bombing. These factors made mines an especially potent threat to what remained of Japan's merchant fleet and naval forces.

"Outer Zone" Results

In the Japanese "outer zone" the forces committed to mining were usually spread thin and lacked the support of the Allied high command. Though this strategy prevented mining from having a decisive impact on the overall course of the war, the Bombing Survey emphasized the effects were large in proportion to the effort expended. "[5]

Of the approximately 13,000 mines laid in Japan's "outer zone," aircraft dropped 9,254 from 3,231 sorties to create 108 minefields. Across this large area, aerial mining sank or damaged as many as 405 ships amounting to 776,260 tons at a cost of 40 Allied aircraft.[6] Though difficult to measure, the Bombing Survey stressed, "Even more important was the fact that vita] shipping was greatly hampered in its movements and delayed for periods ranging from a day or two to a month."[7]

After some ports were mined, such as Rangoon and Haiphong, large ships seldom visited them, while mines frequently closed numerous others, such as Shanghai, Hong Kong, Takao, Bangkok, Singapore, Balikpapan, and Surabaya. Mining a1so convinced the Japanese Navy to abandon anchorages at Pa1au, Penang, and Kavieng. The disruption of merchant traffic, in turn, caused supp1y problems for the Japanese Army deployed in China, Burma, Siam, Malaya and Indochina. The Bombing Survey specifically credited the mining of an in]and waterway, the Yangtze River, with having a blockading effect that significant]y hampered Japanese Army offensives in China during 1944-45.[8] This action prompted the Survey to suggest: "The successes obtained helped prove the value of the aerial mine as an air force weapon."[9]

"Inner Zone" Results

The Transportation Division of the Bombing Survey described the concentrated B-29 minelaying of Operation Starvation as "among the most significant contributions of Army air in the strategic war against merchant shipping." The report cited four main contributions to the allied war effort against Japan: It greatly reduced the remaining merchant shipping, virtually closed the vital Shimonoseki Strait

and ports not accessible to submarines, denied access to repair yards, and threw the administration of shipping into "hopeless confusion."[10] Japan/s former prime minister, Prince Fumimaro Konoye, said in October 1945 that the aerial sinking of Japanese vessels and the B-29 mining of harbors were equally as effective as the B-29 attacks on industry.[11] Similarly, Takashi Komatsu, director of a Tokyo steel company, stressed that although bombing badly hurt factories, the denial of essential raw materials to them was a greater loss.[12]

Indeed, "Operation Starvation" sank more ship tonnage in, the last six months of the war than the concentrated efforts of all other sources combined. The Twentieth Air Force flew 1,529 sorties and laid 12,135 mines in twenty-six fields on forty-six separate missions. Mining demanded only 5.7 percent of the XXI Bomber Command's total sorties, and fifteen B-29s were lost in the effort--just under a one percent loss rate.[13] In return, mines sank or damaged 670 ships totaling 1,251,256 tons.[14]

Japanese Mine Countermeasures

Throughout the war, the Japanese were unprepared to counter the mine threat. Despite the dispersed nature of the "outer zone" campaign, they were frequently surprised due to Allied success in keeping the missions secret and also from their own failure to communicate between commands. Their handicaps in minesweeping amplified the effect of relatively small Allied efforts that used unsophisticated magnetic and acoustic mines.

A result of Japan's failure to anticipate Allied mining capability was their inability to counter "Operation Starvation." By then, shipping had become so critical that they hastily gave mine countermeasures a top priority--to the point of using small suicide craft to detonate mines as well as drawing searchlights and antiaircraft artillery away from cities to the most important mining targets. The Bombing Survey estimated that by war's end the Japanese had 35,715,340 yen, 20,000 men, and 349 ships devoted to defense against the mining campaign.[15] They also suffered from a lack of cooperation between scientists and the military, but nonetheless devised methods to sweep all varieties of mines except the new low-frequency acoustic and the pressure types.

Meanwhile, Commander Johnson and the Mine Modification Unit at Tinian worked constantly,

tailoring each new minefield to frustrate Japanese countermeasures as much as possible. Johnson used timely intelligence derived from surveillance of enemy sweeping techniques, knowledge of the target areas, and the results of earlier mine drops to add the appropriate firing mechanism. In this way a few basic mine types could be modified to yield a great many possible combinations. Though the campaign constantly suffered from a shortage of the desired kinds of assemblies, the Japanese Navy was far from mounting a credible mine defense. Just after the war, Captain Kyugo Tamura, a Japanese minesweeping officer, stated:

> The result of B-29 mining was so effective against the shipping that it eventually starved the country. I think you probably could have shortened the war by beginning earlier.[16]

World War II Conclusions

The Strategic Bombing Survey praised both the efficiency and effectiveness of aerial minelaying against Japanese shlpping.[17] On the whole, minelaying complemented submarine and air attacks on shipping, as did the bombing of ports, industry, and land transportation systems. The report stressed the importance of advance preparation, the ability to make large initial attacks that could be continued, and the need for close liaison between the Navy and Air Forces. [18] Experience showed inland waterways particularly vulnerable to mines, while in other areas the effectiveness rate was 20-25 mines laid for each ship casualty. The Survey recognized the contributions of countermeasures experts as well as mine designers. Additionally, the Naval Analysis Division of the survey judged aircraft "to be generally superior to other means of laying mines" and that mines, like bombs, should be considered "important air force weapons."

That aerial minelaying, particularly in Operation Starvation, was successful is undisputed. However, mining's impact on the blockade is hard to separate from the concurrent effects of submarine and air attack, as well as fuel and vessel shortages. Of the 8.9 million tons of merchant shipping sunk or damaged, the Bombing Survey's "Summary Report" credits 54.7 percent to submarines, 30.8 percent to air attack, 9.3 percent to mines (largely dropped by B-29s), and the remainder to gunfire and accidents.[19] Though mining/s contribution appears small, it primarily represents the four and a half month effort in

1945 compared to the forty-four and a half month submarine campaign. The relative costs substantiate the Survey's claim "that minelaying has been the most economical in both men and material of all types of warfare against shipping."[20] In another assessment of the minelaying campaign, S.W. Roskill, a British naval historian, wrote:

> The blockade had, in fact, been far more successful than we realized at the time. Though the submarines had been the first and main instruments for its enforcement, it was the air-laid mines which finally strangled Japan.[21]

CHAPTER 6
AERIAL MINELAYING -AN AIR FORCE MISSION

> Since the B-29 mining campaign demonstrated for the first time that air power can carry the brunt of a strategic blockade of a powerful maritime nation, it is recommended that this...be given careful consideration and evaluation in future military planning. [1]
>
> Phase Analysis of Strategic Mining Blockade, 1945

These remarks came from Lieutenant General Nathan F. Twining, Twentieth Air Force Commander at the end of the war. The U.S. Army Air Forces, together with two allied air forces--the RAF and RAAF--had delivered ninety-seven percent of the aerial mines used offensively in World War II/s Pacific theater. Land-based air power had demonstrated a new and lasting role in a maritime environment.

Contributions of the Army Air Forces

Mining during World War II, on any scale, had to overcome more than the absence of established doctrine and centralized control. At issue were serious questions of service autonomy and traditional roles, not to mention the convictions of some very strong-willed commanders.[2] The official history of the AAF suggests air leaders shared a special concern that failure to go along with the mining initiative might allow "major usage of long-range aircraft to develop, by default, into a matter of special interest to the Navy.I'3 Meanwhile, Navy commanders foresaw AAF encroachment on a naval mission, and some decried the Air Forces taking all the credit.[4]

Kenneth Veth, a Navy lieutenant commander who served as Mountbatten's mine warfare officer in 1944 and who retired as a rear admiral, praised "the flexibility of thought of those Air Force leaders who authorized the diversion of some aircraft from their traditional bombing role to that of aerial mining."[5] One can only speculate as to why General "Hap" Arnold ordered the B-29 mining campaign despite the conflicting views of most members of his air staff. Arnold’s decision certainly required boldness and "flexibility of thought" at a time when he focused on strategic bombing to demonstrate the independent capability of air power and lay the foundation for an autonomous Air Force. However, B-29 minelaying demonstrated the flexibility of air power and exposed the Air Force to a traditional Navy

mission--sea control.

On September 20, 1945, the final edition of the Twentieth Air Force memorandum, "Weekly Status of Mine Warfare Progress" had little to report: Plans, training, and operations were complete, and the 313th Bomb Wing Mining operations had ended. The intelligence section concluded the memo with a justifiable expression of pride:

> Historically, this is the first time that directs blockade has ever been achieved by other than opposing sea power. Apart from the actual damage done to the enemy, this achievement of air power adds an important new factor to the traditional concepts of the methods to be used in defeating an opposing maritime nation.[6]

Mines and the Postwar U.S. Air Force

Immediately following World War II the Army Air Forces maintained an interest in minelaying, even as military forces fell victim to massive post-war reductions.[7] Major General Curtis E. LeMay, now Deputy Chief of the Air Staff for Research and Development, began a study in 1946 "to determine the extent to which the AAF should control the development of aerial mines and their employment as a strategic weapon."[8] LeMay solicited comments from other sections of the Air Staff. Major General O.P. Weyland, Deputy for Plans, responded: "All war plans... envisage the application of aerial mine warfare to the limit of its effectiveness." Furthermore, he wrote, "It has been assumed that the control of strategic offensive aerial mining...will remain with the Air Forces."[9] The Deputy for Operations, Brigadier General Thomas S. Power, argued, "It Is obvious that if aerial minelaying were a pure Army project from initial research thru tactical employment. a great increase in efficiency and economy would be effected." He advocated the development and stockpiling of mines independently of the Navy.[10]

Despite the rhetoric, post-war plans did little to keep operational units ready for the minelaying mission. An exception occurred on November 28, 1947, when Lieutenant General Lauris Norstad, the new Deputy Chief of Staff for Operations, informed General George C. Kenney, Commander of Strategic Air Command (SAC), that Headquarters Air Force would add aerial mining to SAC's responsibilities.[11] Kenney promptly directed one unit (the 307th Bombardment Group) to become proficient at minelaying, but soon other pressures would allow SAC's commitment to maritime missions

fade.

Since the new U.S. Air Force had gained its independence with the National Security Act of 1947, growing tensions between the services over roles and missions resulted in the "Key West Agreements" of March 1948. The Air Force's newfound autonomy and increasing preoccupation with strategic nuclear attack made it easy for the service to relegate maritime air tasks to a secondary responsibility. The Joint Chiefs of Staff agreed that the Navy was the primary service responsible for air operations in naval campaigns, air superiority and reconnaissance in naval operations, antisubmarine warfare, and aerial minelaying.[12] The Air force assumed a collateral role in these same duties at sea.

Today's definition of service responsibilities has changed little since Key West.[13] Current doctrine assigns primary sea control duties to the Navy, while the Air Force is responsible for collateral missions of sea surveillance, interdiction, anti-Submarine warfare, anti-air warfare, air-refueling, and minelaying. As a result of this delineation of responsibility, the USAF has had no positive incentive to improve its mining capabilities, since a collateral mission could not be used to establish additional force requirements. Though this constraint limited the nation's ability to wage offensive mine warfare, the Air Force has yet to be called on to execute mining in limited wars.

Still, the growing Soviet naval threat prompted the Air Force and Navy to expand joint planning and participation in maritime air operations. In 1975 Chief of Staff David C. Jones and Chief of Naval Operations Admiral James L. Holloway signed the "USAF-USN Collateral Functions Agreement." As a result, Strategic Air Command's B-52 bomber crews began regular training for "Busy Observer" sea surveillance missions, practiced aerial minelaying, and conducted anti-shipping exercises with those aircraft modified to carry the very potent "Harpoon" missile system. Staffs at both the Navy Mine Warfare Command and the Air Force Strategic Air Command exchanged officers and ensured that worldwide contingency plans accommodated joint contributions to win the war at sea.

Fig. 6: A 43rd Strategic Wing B-52D participating in a minelaying exercise. (USAF Photo, 1982)

Mines in Three Limited Wars

In the fifty years since World War II, sea mines were a factor in thirteen conflicts and today can be found in the arsenals of 43 nations.[14] Wartime aerial minelaying achieved significant results only once during this period (in Vietnam), but it continues to be a credible means of maritime blockade--as it was in 1945. Despite the worldwide proliferation of mines, lean budgets and parochial ism during interwar years have caused periods of neglect for mine warfare in the U.S. Navy. However, the lack of preparedness to counter mines during conflicts in Korea and the Persian Gulf, along with America's own mining in Vietnam, reinforced lessons regarding the deadliness of mines to lines of communication.

In 1950 mines in Korea again demonstrated their effectiveness as a barrier.[15] General Douglas MacArthur planned to move 50.000 troops of the First Marine Division and X Army Corps by sea from the west coast of the peninsula to Wonsan harbor on the east for a landing on October 20th. However.

Russian advisors had helped the North Koreans lay up to 3.000 mines to block such an assault. A gallant but hastily assembled minesweeping force lost five ships to the mines while United Nations (U.N.) forces waited offshore almost a week longer than planned. U.N. ships also had to clear mines from the ports of Chinnampo and Hungnam before the war's end. The Navy's frustration with mines in Korea prompted the Commander of Naval Forces in the Far East, Vice Admiral Turner Joy, to state. "The main lesson of the Wonsan operation is that no so-called subsidiary branch of the naval service, such as mine warfare, should ever be neglected or relegated to a minor role in the future."[16] Hardly forgotten, the Navy was eager to use mines offensively for a conflict in the next decade.

Early in the Vietnam war, many American military leaders advocated mining since most of the North's military and economic assistance came by sea.[17] In fact, a full 85 percent of the country's imports passed through the sing1e port of Haiphong. In a postwar interview, Admiral Thomas H. Moorer said. "I think both the Johnson and Nixon administrations were about eight years late. I first recommended mining Haiphong in 1964 when I was Commander-in-Chief of the Pacific F1eet." Moorer added, "In my opinion, the failure to mine Haiphong immediately was the difference between winning and losing in Vietnam." [18] Due to the character of the war in Southeast Asia at that time (substantially a guerril1a war fought in the South), the efficacy of mining so early in America's inv01vement is questionable. However, it was political restraint, motivated by the United States negative objective of preventing Soviet or Chinese intervention, that then prohibited a large-scale mining effort.[19]

As the war dragged on, President Lyndon Johnson escalated military action against North Vietnam, and in February 1967 allowed the Navy to mine five inland waterways (the Song Ca, Giang. Song Ma, Kien, and Cua Sot Rivers). The bombing campaign of "Rolling Thunder" begun in March 1965, had put pressure on the road and rail system and seemingly increased the importance of movement by barge and sampan. By April 1967, carrier-based A-6 aircraft laid the river minefields and caused the enemy to shift water-borne supplies back to already heavily burdened truck transport over jungle roadways at night. Still, the most lucrative targets--three main deep water ports (Haiphong, Hon Gai, and Cam Pha) remained off-limits to mines for another five years.

Over that time crucial changes in the nature of the war, in Cold War relations, and in the White House widened the possibilities for mine warfare. In the spring of 1972, the North Vietnamese mounted a conventional invasion of the South by twelve divisions which proved highly vulnerable to air power. Meanwhile, the United States relations with the Soviets and Chinese had so improved that President Richard Nixon could direct the mining of North Vietnam's ports without fear of intervention.[20]

After years of awaiting the order, carrier attack aircraft would now close Haiphong with mines. While the planes were airborne, the president announced that ships in port had three days to leave before the mines activated. Five elected to depart, but neither the 27 ships remaining, nor any from outside, challenged the minefield for the next nine months. Aircraft also mined other harbors, river entrances, and areas along the coast--against none of which could the North Vietnamese mount a serious minesweeping effort. The mines did not need to sink ships to be effective, since traffic through deep water ports fell from forty ships per month to zero.[21] The mines were "on duty" twenty-four hours a day without unduly exposing friendly forces to hostile fire. Moreover, since mines were passive "weapons that wait," they facilitated a blockade without aggressive action toward the shipping of non-belligerent nations, which previously traded with North Vietnam. Ultimately, Navy aircraft laid 8,000 mines during the war, and by successfully blockading the harbors to external supplies; they helped thwart the 1972 Communist offensive.[22]

Conditions necessary for the successful employment of mines included the right political circumstances, the vulnerability of the enemy, and the preparedness of U.S. forces. The mining campaign required an adequate stock of the right types of mines, logistical readiness to sustain the minefields, aircraft to deliver the weapons, and thorough target intelligence. At the time, the mine inventory received a boost from the Navy's recently developed "Destructor" series (DST) munition. The DST simply used a fusing kit that converted a general-purpose bomb into a low-cost mine.23 Almost any tactical aircraft could carry these adaptable weapons. which required no minimum water depth and hence were well suited for rivers and channels. Had North Vietnam, or one of its allies, made attempts to clear the mines, an American capability for reseeding those waters would likely have confounded any

such minesweeping efforts. If the United States fully recognized the capability of mines against North Vietnam, it would appear that by the 1980s the lesson of Wonsan, Korea was forgotten: that U.S. forces were highly vulnerable to an enemy mine threat.

Crisis in the Persian Gulf, during the Iran-Iraq War and "Desert Storm." again demonstrated the need for preparedness in mine warfare. There, low-cost sea mines threatened the Navy's ability to operate. In 1988 the tanker Bridgeton suffered a blow from a mine and much more serious damage was done to an American warship, the Samuel B. Roberts (FFG-58). On April 14th a "primitive" moored contact mine, valued at under $1,500, nearly sank that ship and caused damage costing $52.1 million to repair.[24]

In 1990, as the United Nations coalition forces massed following Saddam Hussein's invasion of Kuwait. Iraq dumped over 1,000 mines (consisting of 16 varieties with eight contact and eight influence types) into the Persian Gulf.[25] Coalition casualties occurred on February 18th when a moored contact mine with 300 pounds of explosive ripped a 16 x 20 foot gash in the Tripoli (LPH-10), an amphibious assault ship that had been directing the mine clearing. Three hours later, two influence mines damaged the Princeton (CG-59), an Aegis class cruiser in the same area. All told, mine clearance required "extraordinary" efforts, including a coalition force of sixteen minesweeping ships from four countries plus a detachment of mine countermeasure helicopters and support vessels. From a strategic view, the Gulf made an ideal target.

The Lessons - Are They Learned?

Mines have proven themselves as effective and highly economical weapons across the spectrum of conflict. Today, so-called "primitive" mines can sink or damage valuable ships, while modern mines have vastly greater capability. Yet, just as officers claimed over fifty years ago, the statement is again made, "Mine warfare can/t get no respect in the world's most powerful Navy."[26] It is helpful to appreciate the character of these institutions--the Army, Navy, and Air Force--to understand why such promising weapons tend to be neglected.

In The Masks of War, RAND analyst Carl Builder describes now each service creates its own

image of war that reflects the perceived essence of the service--"who it is and what it is about." He labels mine warfare as a "fringe element," traditionally treated as a less attractive obligation in the clamor for attention (and funds).

> Mine warfare is a stepchild in the Navy, despite those who warn that it could, and has occasionally, become the central aspect of naval warfare. Playing around with mines--sowing them or sweeping them--is simply not the kind of business with which the Navy likes to be associated.[27]

Thus, in spite of their potential, the services tend to ignore weapon systems that do not conform to their perceptions of a "proper" mission. Naval mines, air force unmanned air vehicles, and army special forces all fit into the category of "stepchildren" in the American military arsenal.[28] Such an understanding of institutional "personalities" helps, in part, to explain the failure of the services to embrace "unpopular" weapons or tasks in spite of their combat potential. Commanders should consider mining's past lack of acceptance to anticipate the obstacles they will likely confront in the future.

Future Applications

Minelaying makes a direct application of force with effects that may be auxiliary to a land or sea battle, but which have the potential for attaining objectives independent of surface combat. Aircraft combine a highly effective means for delivery with weapons which can influence both the will and capability of an adversary. In the first case they interfere with, or deny, the enemy/s strategy by sinking ships, creating a barrier, or cutting needed supplies. Then, to impact the enemy will, mine warfare can impose potentially intolerable military or economic pressure.

Since the Vietnam experience, the United States has shown an increased interest in a maritime defense strategy to project (naval) power while avoiding commitment of ground forces to influence Third World disputes. The Air Force contributes to this strategy with "Global Reach--Global Power" capabilities stressing mobility, deployability, and long-range combat aircraft for power projection.

To accomplish minelaying the Navy develops and maintains an arsenal of mines which can be delivered by their land-based patrol planes or carrier strike aircraft. However, as in World War II, the Air Force could be called on to deliver mines where the mission required long-range, large payload

aircraft like the B-52, B-1, and B-2 bombers, or even transports, such as the C-130 and C-141. The preferred aerial ordnance for conventional warfighting will likely continue to be precision guided munitions, and modern mines could be considered in that class. Mines today are more sophisticated and capable than ever, using microprocessors for increased autonomy, as well as detection and identification of targets.

Potential locations for offensive aerial mining include any nation's inland or coastal waters, specifically where there is military or commercial use. Mined areas would ideally be chokepoints, such as straits or narrow channels, but could even be open ocean where deep water anti-submarine mines can still operate. Scenarios for mining could vary from enforcement of sanctions, embargo, and blockade to low-intensity conflict and any degree of conventional war. In any case, mines have been proven as flexible, effective weapons, and air power lends versatility that will keep them viable for the indefinite future.

Conclusion

The capability that the U.S. Air Force lends to the sea service in the 1990's is considerably advanced from that which the German air force offered its navy when it carried out the first combat aerial minelaying in 1939. The United States own experience in World War II was pivotal, when a small number of mining advocates influenced wartime commanders to ensure advances in minelaying equipment, doctrine, and strategy. Mine warfare, building on over two hundred years of history and theory, could finally mature when matched to the aircraft/s characteristics of speed, range, and flexibility. As the war in the Pacific demonstrated--and more recent events have reinforced--the Air Force and minelaylng have earned important roles in the naval mission known as sea control.

Fig. 7: "Mines Away!" A Strategic Air Command B-52G releases a sea mine. (USAF Photo, 1985)

NOTES

Introduction

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4. Robert C. Duncan, America's Use of Sea Mines (White Oak, Maryland: U.S. Naval Ordnance Laboratory, 1962), 164-165.
5. For the current official description of mine warfare operational principles, doctrine, and military guidance in the U.S. armed forces, see Joint Pub 3-15, Joint Doctrine for Barriers. Obstacles and Mine Warfare {Washington, D.C.: Joint Chiefs of Staff, (Final draft) January 1992).
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1. Cajus Bekker, Hitler's Naval War (Garden City, New York: Doubleday, 1974), 71-72. Also, see William B. Boyd and Bufora Rowland, U.S. Navy v Bureau of Ordnance in World War II, by the Bureau of Ordnance, Department of the Navy (Washington, D.C.: Government Printing Office, 1953), 159. Boyd and Rowland describe the American magnetic mine by June 1940 as "so inferior to the German device, one of which was furnished by the British, that it was decided to copy the German mine...[subsequently] designated Mark 12...which cou1d be planted by submarines, surface vessels, or aircraft."
2. Ibid., 71.
3. Ibid., 73. Regarding the rift between the Luftwaffe and Navy over aerial minelaying, see also Friedrich Ruge, Sea Warfare 1939-1945: A German Viewpoint, translated by M.G. Saunders (London: Cassell, 1957), 52. 96-97.

4. Hartman and Truver, 242. See also, Arnold S. Lott, Most Dangerous Sea: A History of Mine Warfare Account of U.S. Navy Mine Warfare 0perations in World War II and Korea. (Annapolis, Maryland: U.S. Naval Institute, 1959). Even the U.S. did not escape German U-boat mining off the East Coast where they placed 338 mines. These sank four ships and damaged another six. More importantly, though, they caused a U.S. reaction to close ports, instal1 anti-submarine nets, assign up to 125 minesweepers, and field defensive mines, which, though never sinking a U-boat, damaged or destroyed 15 friendly vessels.
5. “Minelaying By Bomber Command," Air Power 7 (Summer 1960): 263. Note that in addition to Bomber Command's mining, RAF Coastal Command laid 841 mines.
6. L.R.N. Ashley, "The Royal Air Force and Sea Mining in World War II," Air University Quarterly Review 14 (Summer 1963): 39. Regarding Harris proposal for the magnetic mine and the record of interservice cooperation, see also Dudley Saward, Bomber Harris (Garden City, New York: Doubleday, 1985), 55-57, 89.
7. Arthur Harris, Bomber Offensive (New York: Macmillan, 1947): 138-139. Note that concerns within the U.S. Army Air Forces for the primacy of bombing over mining, along with interservice relationships, similarly influenced the American minelaying efforts that came later. See also, Cowie, Mines, Minelayers and Minelaying, 195. "Teamwork was the underlying reason for the success of the allied minelaying campaign, and lack of it was the cause of the Axis failure."
8. Ashley, 40.
9. Harris, 138.
10. J.S. Cowie, Mines. Minelayers and Minelaying (London: Oxford Univ. Press, 1949), 160.
11. Roy F. Hoffman, "Offensive Mine Warfare: A Forgotten Strategy," U.S. Naval Institute Proceedings 103 (May 1977): 148.
12. Denis Richards and Hilary St. George Saunders, Royal Air Force 1939-1945, Vol. II, The Fight Avails (London: Her Majesty's Stationery Office, 1954), 99.
13. L.F. Ellis and A.E. Warhurst, Victory in the West, Vol. II, The Defeat of Germany (London: Her Majesty’s Stationery Office, 1968), 228. This official history also lists 17 U-boats sunk and another 17 damaged. Altogether, from April 1940 until the end of the war in Europe, the RAF laid 48,148 mines at a cost of 535 aircraft lost. According to British naval historian, S.W. Roskill, "minelaying provided by far the biggest contribution made by Bomber Command to victory at sea."
14. Hartman and Truver, 242.
15. Harris, 39. See also, Ashley, 39. 16. Duncan, 168. See also, Ashley, 41.

Chapter Three

1. Ellis A. Johnson and David A. Katcher, Mines Against Japan (White Oak, Maryland: U.S. Naval Ordnance Laboratory. 1947; reprint, 1973), 41. Also, see Boyd and Rowland, 159. They describe mine development from 1918-1939 as "virtually dormant" due to the very small staff provided the Naval Ordnance Laboratory (NOL). German mining spurred expansion, but NOL priority went first to countermeasures, then defensive mines, and more slowly to offensive mines. Also, Hoffman, pp. 149--150. Rear Admiral Hoffman described mine warfare at the beginning of World War II as “hampered and diluted by poor preparedness." He called readiness "pathetic...not much different from that existing at the end of the previous war." Hoffman was also critical of the U.S. failure to adopt a strategic mining plan until the last year of World War II.
2. Duncan, 137. The author, former Chief Physicist for the U.S. Naval Ordnance Laboratory, gives the total supply of aerial mines on December 7, 1941 as 200 Navy Mk. 12 ground, magnetic types. Also see Boyd and Rowland, 160. The only American mine which could be air delivered at the start of the war, the Mark 12, was based on the captured German magnetic mine, Itself dating to a 1920/s design. "It could be handled only from wing or torpedo racks, and few types of long range aircraft were available for minelaying."
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5. Headquarters, XXI Bomber Command, 20th Air Force, "Narrative History. 1 Mar 45-31 Mar 4511, 11. AFHRA file number 762.01 V.l.
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24. Ibid., 10.
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12-13.
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Aerial Mining Operations in the Southeast Asia Area Between 1 Mar 1944 and 1 Oct 1944. AFHRA file number 825.491.
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6. Headquarters Twentieth Air Force, "Weekly Status of Mine Warfare Progress as of 19 Sept 45," (dated 20 September 1945), 2. AFHRA file number 760.549.
7. Air University project 4745 "USAF Responsibilities in Mine Warfare." AFHRA file number K239.0429-4745AU. In a letter dated 10 May 1948 to the Commander of Air University, Major General E.E. Partridge wrote, "It is envisioned that the Air Force will still be called upon for almost al I long-range aerial mining operations. The Navy has informally concurred in this viewpoint."
8. In 1946 EI I is Johnson, LeMay's mining advisor in 1945 (and now a civilian in the naval reserve), corresponded with his old boss. Johnson wrote a manuscript titled "Control of the Seas by Means of Air Power" and sent it to LeMay for his review. One of the conclusions was "cognizance over mining should be transferred to an air arm." In his accompanying letter, Johnson suggested "The AAF are best prepared psychologically and by experience.. .to carry out strategic minelaying operations. LeMay replied, "Undoubtedly the implementation of an aerial mining program by the AAF would strengthen our Strategic Air Arm and render it more capable of accomplishing its mission." Letter from E.A. Johnson to Lemay 3 Sep 46. Letter from Maj. Gen. Curtis E. LeMay to E.A. Johnson, 22 Oct 1946. AFHRA file number 168.64-17.
9. Letter from Major General O.P. Weyland (AC/AS-5) to AC/AS-3 and AC/AS-4 dated 14 Oct 1946. Subject: "Strategic Effectiveness of Aerial Mine Warfare." AFHRA file number 168.64-17.
10. Letter from Brigadier General Thomas S. Power (AC/AS-3) to AC/AS-4 and DC/AS, Research & Development, dated 20 Nov 46. Subject: "Strategic Effectiveness of Aerial Mine Warfare." AFHRA tile number 168.64-17.
11. Maurice A. Mi1ler. The Collateral Maritime Mission Strategic Air Command (_U) (Omaha, Nebraska: Office of the Historian, Strategic Air Command. 31 Dec 1980), 18. AFHRA fi1e number K416.04-28c.l.
12. Robert Frank Futrell, Ideas, Concepts, Doctrine, Vol 1., Basic Thinking in the United State Air Force 1907-11960 (Maxwell AFB, Alabama: Air University Press, 1989), 198. See also, Robert C. Kuhlo, Attacking Ships: Command and Control of Joint Antiship Operations (Maxwell AFB, Alabama: Air University Press, 1990), 5-7.
13. See Department of Defense Directive 5100.1 (excerpts in Kuhlo, Attacking Ships, above). Also, JCS PUB 0-2, Unified Action Armed Forces (Washington. D.C.: Joint Chiefs of Staff, 1 Dec 1986), 2-13.
14. J.M. Martin, "We Still Haven/t Learned," U.S. Naval Institute Proceedings 117 (July 1991): 68. See also, Hartman and Truver, 245. Among the more noteworthy mining efforts since WW II are: Korea. 1950; Vietnam, 1965-1972; India-Pakistan. 19-71; Falklands (Malvinas), 1982; Nicaragua, 1984; Red Sea/Gulf of Suez. 1973 and 1984; and the Persian Gulf in 1987-88 and again in 1991.
15. Colletta. 21-24. For a complete account of countering the mines in Korea. see James A. Fie1d. Jr. History of Naval-Operations: Korea (Washington, D.C.: Government Printing Office. 1962), 229-250.
16. Quoted in Thomas Bradley, The Use of Air Power in Joint Maritime Operations (Maxwell AFB, Alabama: Air University Press, 1985), 71.
17. Vice Admiral Malcolm W. Cagle wrote as one of the "major lessons of the air war:" "In the opinion of most naval and military experts, the single military action which could have hurt North Vietnam

most would have been the closing of Haiphong." Other outspoken advocates of mining included Lieutenant General Victor H. Krulak, USMC; Admiral U.S. Grant Sharp, USN; General William Westmoreland, USA; and General Earl Wheeler, USA. See M.W. Cagle, "Task Force 77 in Action Off Vietnam," in Vietnam: The Naval Story, Frank Uhlig, Jr., ed. Annapolis, Maryland: Naval Institute Press, 1986; V.H. Krulak, "A Conflict of Strategies," U.S. Naval Institute Proceedings 110 (November 1984): 84-90; also, U.S.G. Sharp, Strategic for Defeat: Vietnam in Retrospect. Novato, California: Presidio Press, 1978; and, D.Chamberland, "Westmoreland Interview," U.S. Naval Institute Proceedings 112 (July 1986): 47.

18. Quoted in Timothy J. Christman, "Mining Haiphong Harbor," Naval Aviation News (September-October 1986): 14-15.
19. Ulrik T. Luckow, "Victory Over Ignorance and Fear: The U.S. "Minelaying Attack on North Vietnam," Naval War College Review (January-February 1982), 19-21.
20. Ibid.. 18-21.
21. Christman, 15.
22. Luckow. 24.
23. The Destructor (DST) series mines are conversions of general purpose low drag bombs. For example the Mk 82, 500 pound bomb becomes the Mk 36 mine; the Mk 83, 1,000 pound bomb becomes the Mk 40 mine; the Mk 84, 2,000 pound bomb becomes the Mk 41; and the Mk 117 750 pound bomb becomes the Mk 117D. The "Quickstrike" series is a newer, but similar modification with designations of Mk 62, 63, and 64. These, and more complex mines, are described by Sheila Galatowitsch, "Undersea Mines Grow Smarter and Deadlier," Defense Electronics (March 1991), 57-64.
24. Martin. 64-65.
25. Ibid., 64-66.
26. C.F. Horne, III, "Mine Warfare Is With Us and Will Be With Us," U.S. Naval Institute Proceedings 117 (July 1991): 63. The author, Admiral Horne, was Commander Mine Warfare Command and currently serves on the Mine Countermeasures Technology Study under the auspices of the Academy of Sciences.
27. Carl H. Builder, The Masks of War (Baltimore, Maryland: John Hopkins University Press, 1989), 131.
28. Ibid., 202.

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