CAN LOGISTICS AND MAINTENANCE TAKE ATOLL? ADAPTIVE LOGISTICS AND MAINTENANCE FOR TOMORROW'S ISLAND-HOPPING

BY

MATTHEW S. STEWART, MAJ, USAF

A THESIS PRESENTED TO THE FACULTY OF
THE SCHOOL OF ADVANCED AIR AND SPACE STUDIES
FOR COMPLETION OF GRADUATION REQUIREMENTS

SCHOOL OF ADVANCED AIR AND SPACE STUDIES
AIR UNIVERSITY
MAXWELL AIR FORCE BASE, ALABAMA
JUNE 2019

APPROVAL

The undersigned certify that this thesis meets master's-level standards of research, argumentation, and expression.

_____

LT COL NATHANIEL HUSTON (Date)

_____

COL STEPHEN RENNER (Date)

DISCLAIMER

The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

ABOUT THE AUTHOR

Maj Matthew S. Stewart received his commission through the ROTC program at Texas Christian University in 2006. He began his career as a C-130 navigator and, later, became a pilot with over 750 combat hours across three deployments. His operational experience expands across multiple theaters, to include Operations Iraqi Freedom, Enduring Freedom, New Dawn, and Inherent Resolve. Maj Stewart also worked at Headquarters Air Force in the Directorate of Strategic Plans and the Directorate of Programs. He is a graduate of the Blue Horizons Fellowship at Maxwell AFB, AL. During Blue Horizons, Maj Stewart led a team that prototyped a future aircraft maintenance concept called the Agile Maintenance Ecosystem. In June 2019, he was assigned to the 435th Contingency Response Squadron at Ramstein Air Base in Germany.

ACKNOWLEDGMENTS

This research project would have never happened without the monumental efforts and time given by Lt Col Nathaniel Huston. I am extremely thankful for his dedication from the initial topic selection to honing my argument to polishing the final product. He continuously challenged me to strengthen this paper, and for that, I am tremendously grateful. Additionally, thank you to the reader of this thesis, Col Stephen Renner, for his mentorship and direction. Col Renner's and Lt Col Huston's patience and guidance were vital to the accomplishment of this research.

Most importantly, thank you to my family for the love, patience, and humor along the way. Your smiles bring me joy, and your love is contagious. To my wife, I love you. Thank you for always encouraging me and providing strength and joy for our family. To my kids, I love you and cannot wait to see what the future holds for each of you.

ABSTRACT

In World War II, Admiral Nimitz and General MacArthur set out to defeat an entrenched enemy throughout several island chains situated thousands of miles away. The United States mobilized and shipped hundreds of thousands of troops and thousands of aircraft to places throughout the Pacific theater. The lack of existing logistical infrastructure like ports, airfields, and storage, increased the difficulty of island-hopping. Additionally, the rapid growth in number of aircraft meant an immediate deficit of aircraft mechanics and parts. The United States changed the training model for maintainers, trained civilians to work in maintenance depots, and created floating supply ships to gain operational advantages. The lessons from this case study offer insight into what a conflict in the Pacific might look like today. This study utilizes those lessons and analysis and applies the lessons into the future.

Contents

Illustrations

Chapter 1

Introduction

The 2017 National Security Strategy (NSS) attempts to refocus the United States' efforts back to great power competition and specifically calls attention to the rise of China's global influence. The NSS declares that China's rise in the Indo-Pacific region is occurring at the expense of the sovereignty of other nations.[1] As the United States meets China's rise with resistance, a conflict between the two powers becomes more likely. Furthermore, China's claim to islands in the South China Sea and its decision to build up reefs into militarized atolls, along with President Trump's firm stance on the trade imbalance with China, sets the stage for a potential clash.

Disagreements between China and the United States over Taiwan, the South China Sea, economic policies, or a random event could set off a conflict in the Indo-Pacific region. A war with China would present many challenges ranging from their recently modernized military to the economic implications of the two most powerful nations waging war against the other.

If a conflict erupted between the two powers, one element of the United States could pursue is "Adaptive Basing." Adaptive Basing is a deployment construct that provides commanders with operational agility to maneuver from one base to another. Quick hops could provide fuel, munitions, and even crew changes. World War Two (WWII) offers a similar scenario, both involving great power conflict and comparable logistical obstacles. In response to the bombing of Pearl Harbor, the United States fought its way through Japanese-controlled islands to reach Japan in an effort to force surrender. The United States devised a

[1] NSS, 25.

plan, termed island-hopping, to move from one island to another and fight the Japanese at less capable outposts while leapfrogging more fortified bases. The distance between the United States and East Asia presented a problematic hurdle which was exacerbated by the lack of large land masses to build airfields, supply depots, and main operating bases (MOBs). Additionally, the United States deployed thousands of aircraft to remote locations in the Pacific without a comprehensive plan to maintain the deployed aircraft. These two areas, logistics and aircraft maintenance, are the focus of this paper.

In the future, if Sino-American diplomatic options fail and a military conflict takes place, the United States would find itself in a familiar region with similar challenges. This paper seeks to understand the logistics and aircraft maintenance efforts underpinning the island-hopping campaign of WWII and analyze how it might inform future research for Adaptive Basing operations.

Statement of the Research Question and Preview of the Argument

The overarching research question for this paper is: how can the "island-hopping" strategy in WWII inform the current Adaptive Basing concept, with a focus on logistics and maintenance?

Additionally, chapters three, four, and five will analyze the following questions: How did the United States supply a war on the other side of the globe? What enabled these military units to take over an island and quickly set up operations to launch aircraft sorties? What type of maintenance and logistical support made this campaign such a success? How do current plans within the Department of Defense (DoD) approach a scenario of the United States versus China? Could the United States launch aircraft from austere locations and then pick up and quickly move to another location?

Figure 1: Strategy in the Pacific

Source: Stratfor, "Japan's Territorial Expansion 1931-1942," 8 Dec 14.

The United States implemented a sophisticated approach to push the Japanese back and ultimately drive their capitulation. The Japanese occupied land from the Sea of Okhotsk in the North to Indonesia in the South (Figure 1). The expansive control provided resources and fighting locations for the Japanese while presenting logistical complications for the United States. The United States understood the difficulty caused by fighting Japan close to its mainland and conceived a plan to conquer islands to gain momentum. The key to the strategy was taking less fortified islands, which allowed the United States to jump over the more heavily defended ones. The United States successfully implemented a

leapfrogging strategy. However, it was not without difficulties, specifically in the aircraft maintenance and logistics efforts.

Logistical complications arose based on the distance between bases and the forward operating locations. Obtaining parts and equipment, troops, and fuel remained a challenge throughout the war. Chapter 2 will provide a historical overview of the operation. Chapters 3 and 4 will identify specific logistics and aircraft maintenance challenges and explain how the United States approached them, either successfully or not. Chapter 5 will explore the Adaptive Basing concepts to understand how the critical areas in logistics and maintenance efforts of WWII can apply in a contemporary scenario. The conclusion summarizes the analysis and findings within the paper.

Background and Significance of the Problem

The technological advances and globalization that have occurred over the past several decades have changed the way that people perceive distance. China is approximately 5,700 miles away from the contiguous United States. Even Hawaii is over 5,200 miles from the eastern border of the Chinese mainland. There are few suitable operating bases in between the two countries. If the United States and China entered into a war of any size, two of the critical hurdles would be logistical flows and aircraft maintenance in a dynamic scenario.

The United States relies on MOBs in the Pacific to house military servicemembers, aircraft, munitions, and supplies. These MOBs are strategically crucial to ensure quick response times around the world. Kadena, Yokota, and others in the region allow the United States to pre-position assets forward to decrease response times to a crisis as it arises. That said, if a conflict against China began, these bases would likely see ballistic missile attacks that could destroy the bases or at least render them temporarily useless. Also, since these overseas locations are well

known, China could use threats against the host nations to dissuade support.

For these and other operationally relevant issues, the DoD built a concept called Adaptive Basing. This concept is meant to extend the survivability of bases and operating locations that lie within contested environments. Adaptive Basing centers on rapid and flexible mobilization throughout different types of operating locations. To deceive and complicate Chinese plans, Adaptive Basing allows for flexible responses and opens up new options for basing in the Pacific. Moving from base to base with aircraft, supplies, and maintainers to advance on an enemy or to provide deception is not a new idea. In the Pacific during WWII, Admiral Nimitz and General MacArthur implemented an island-hopping campaign to advance toward mainland Japan. Each hop placed American forces in austere locations with minimal resources but allowed them to leap over the most fortified Japanese bases. The following chapter explores the Pacific theater of operations in greater detail for further analysis in later chapters.

Chapter 2

Pacific Theater Case Study

Overview of the Pacific War

This chapter provides an overview of the war in the Pacific, with a focus on the southwestern region. More specifically, it examines the areas under the command of Gen Douglas MacArthur in order to provide background for later analysis. The chapter concludes with a section on island-hopping and presents conditions and difficulties created by such a dynamic and mobile style of war.

The United States had successfully abstained from entering the war in 1941, but President Franklin Roosevelt knew war was on the horizon. In the Atlantic, the United States used naval vessels to track German U-boats and radio the location to the British.[2] Winston Churchill petitioned the US President to come to their aid, but Roosevelt refused to get the United States officially involved. Although Roosevelt wanted to enter the war, many in the United States did not want to, so he used certain acts by the Germans as trigger points. For example, a U-boat fired two torpedoes at an American destroyer in September 1941, so the President issued a "shoot-on-sight" policy. "He neglected to mention that the *Greer* (US destroyer) had been tailing the U-boat for several hours."[3] The President would soon have the reason that he needed to enter the war.

Japanese-American relations began deteriorating in 1937 when Japan invaded China, and by 1939 the Japanese forces controlled a majority of northern China.[4] Japan continued its expansion throughout

[2] Robert J. Maddox, *The United States And World War II* (Routledge, 2018), 85, https://doi.org/10.4324/9780429495786.
[3] Maddox, 82.
[4] Maddox, 85.

the Pacific, taking territory where it could. Japan needed new military bases and airstrips to move farther south. In July 1941, "Tokyo demanded, from the reluctant French, the rights to build naval and air bases and the ability to station troops in southern Indochina."[5] Roosevelt responded by issuing an executive order to freeze all Japanese assets in the United States, but his cabinet interpreted the order more strictly and also banned all oil and gas exports to Japan.[6] The move surprised the Japanese and this policy, in combination with the United States not giving in to Japanese demands, moved Tokyo to order an attack on Pearl Harbor. The US Navy and Army were caught off guard by the attack on Pearl Harbor and lost eight ships and almost 3,000 men.[7]

The United States and Japanese navies clashed across the Pacific after Pearl Harbor, but the United States did not amass a large number of assets and troops until 1942.[8] As the War Department sought a response plan to the Pearl Harbor attack, the Japanese continued their aggressive march through the Pacific. Figure 1 shows the vast expanse under Japanese control prior to the United States fully mobilizing against Japan. The Army and Navy both submitted a plan of attack to push the Japanese out of the southern Pacific. Both plans were similar; they featured amphibious assaults on islands and used the island territory to launch future attacks, but they offered different routes of travel to the Japanese mainland. The Navy wanted to focus on attacking supply lines, but the Army focused on launching massive land assaults throughout dense island chains. The War Department did not pick the Army's or Navy's plan; rather the Department refrained from choosing one plan over the other. Thus, the services took it upon themselves to

[5] Maddox, 88.
[6] Maddox, 88.
[7] Maddox, 93.
[8] Maddox, 109.

enact their own strategies. Instead of a joint venture, the Army set out to enact its own plan, as did the Navy.

Figure 2 depicts the Army and Navy strategies. General MacArthur wanted to take a land-based approach through the Solomon Islands and into the Philippines to strangle the Japanese supply lines. The Navy, however, had a different approach that they wanted to sell to Washington, DC. Admiral Nimitz wanted to push out of Pearl Harbor and take several groups of islands that were much smaller and farther from the Solomon and Philippine islands.

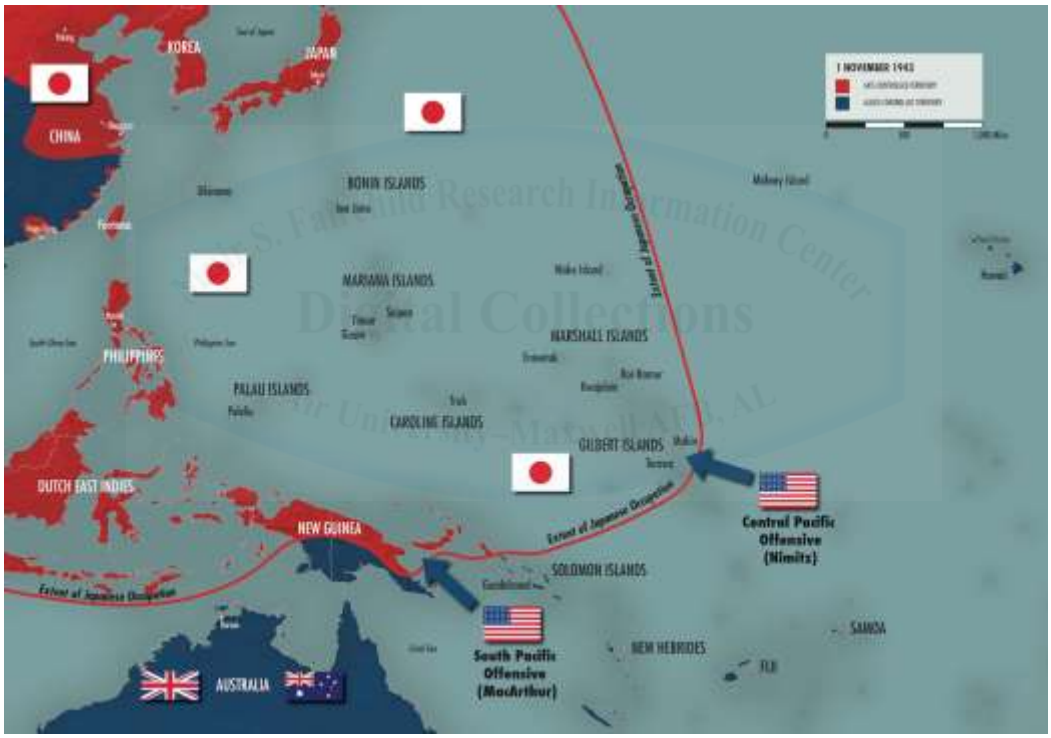

Figure 2: Strategy in the Pacific
Source: The National World War II Museum, "The Pacific Strategy, 1941-1944," 10 July 17.

General MacArthur designed a two-pronged attack that would collide at a decisive battle in Rabaul. Adm William "Bull" Halsey led the eastern push that started with the Solomon Islands and moved

northwest to the north of Rabaul.[9] General MacArthur himself led the western force that began in the southeast corner of Papua New Guinea and worked along the coastline to encircle Rabaul.[10] MacArthur's objective was to continue past Rabaul and retake the Philippines. Controlling both island chains acted as a barrier to cut off supply movements to Japanese-held territory in Burma, Malaya, and the Dutch East Indies.[11] The jungle environment slowed progress, and it took nine months for Adm Halsey and General MacArthur's forces to fully encircle Rabaul. The Japanese outpost at Rabaul needed supplies from the outside, but the supply ships no longer had free movement in the southern Pacific.

The Navy planned to move through the northern island chains and seize airfields, like Kwajalein in the Marshall Islands. The seizure of such airfields provided new places to launch offensive attacks.[12] The amphibious assaults onto unsuspecting islands seemed to offer several benefits that allowed the Navy to stay away from the larger, more heavily defended islands and positioned the US forces closer to mainland Japan in a quicker fashion.

In January 1944, a naval offensive pushed to the Marshall Islands. Nimitz had the carrier-based bombers soften the island before a February 1944 assault. His forces overran Roi island quickly, but Kwajalein was a different story. The US forces needed the power of flame throwers to break down the foliage in the jungle that protected the Japanese troops. Eniwetok followed Kwajalein, skipping a full-scale invasion of the island of Truk.[13] This Japanese-held island was cut off and not needed as a stepping stone toward the objective of mainland Japan.

---

[9] Maddox, 268.
[10] Ronald H. Spector, *Eagle Against the Sun: The American War with Japan* (Free Press, 1985), 204.
[11] https://www.nationalww2museum.org/war/articles/pacific-strategy-1941-1944
[12] Maddox, *The United States And World War II*, 274.
[13] Maddox, 276.

June 1944 brought about amphibious assaults on the Marianas Islands.[14] The Marines stormed Saipan from the north and secured the beachhead by the end of the first day. The bombing that was supposed to soften the Japanese defenses was not as effective as the Navy would have liked.[15] Once word reached Japan that the United States was in the Marianas, the Japanese government sent aircraft carriers. The US Navy's submarines spotted the inbound Japanese carriers and US carriers positioned for a battle. The United States outnumbered the Japanese planes, and the Japanese had lost many of their experienced pilots in earlier campaigns in the Solomon Islands.

The Battle of the Philippine Sea saw three Japanese carriers torpedoed by US ships, one of which was the newest and largest Japanese carrier. They lost over 300 planes in the battle. The United States was so successful in this air carrier battle that it was named the "Great Marianas Turkey Shoot."[16] The impressive win did not come without a cost.[17] The US Task Force Commander, Adm Marc Mitscher, ordered the fighter aircraft to push past their minimum fuel to ensure a victory. As the US planes attempted to return to the US carriers at night, they began to run out of fuel and had difficulties finding their carriers. The United States lost 30 fighters during the fight for the Marianas. After a few more weeks, Saipan fell to the United States, and Tinian and Guam would soon follow.

Having completed the first phase of the Army and Navy strategies, the War Department would, once again, face a decision on the next phase. In the summer 1944, General MacArthur presented phase two of his plan.[18] Phase two sought to liberate the Philippines through

---

[14] Spector, *Eagle Against the Sun*, 285.
[15] Spector, 303.
[16] Spector, 310.
[17] Maddox, *The United States And World War II*, 280.
[18] Maddox, 282.

methodical island-hopping campaigns. President Roosevelt agreed with MacArthur's plan and instructed the Navy to support this phase before returning to their own campaign.

On 5 October 1944, heavy bombardment sank four more Japanese carriers. MacArthur's first landing in the Philippines came in that same month, where he surprised the Japanese by landing at Leyte instead of the main island, Luzon. Within hours, General MacArthur waded ashore, hoisted the US flag, and held a press conference.[19] The battle for Leyte took over two months, in part due to a new tactic by the Japanese Air Force called Kamikaze attacks. The pilots aimed their airplanes at the target and held steady as the plane collided into the intended object. The Japanese successfully used the Kamikaze tactic against US ships, airfields, and troops.

A key lesson learned during the return to the Philippines was that carrier-based aviation provided flexibility to move a group of aircraft quickly to a new location. The flexibility did not always make up for the shorter range, shorter loiter time, and smaller bomb loads.[20] Land-based aviation provided what carrier-based aviation could not, specifically longer range, loiter time, and more munitions. "The leap to Leyte meant that MacArthur would once again rely on aircraft carriers rather than land-based air power for the invasion.[21] Gen George Kenney was hesitant and warned against solely relying on aircraft carriers and wanted to seize airfields within the Philippines quickly to bring in land-based aviation. [22] Island-hopping offered the continued air power that General Kenney desired.

---

[19] Maddox, 284.
[20] Thomas E. Jr Griffith, *MacArthur's Airman : Generaleral George C. Kenney and the War in the Southwest Pacific*, 1 edition (Lawrence, Kan: University Press of Kansas, 1998), 179.
[21] Griffith, 179.
[22] Griffith, 179.

The next step was the island of Luzon, where the United States once again softened Japanese defenses with air attacks. Luzon was strategically important to continue the march to the mainland. On Luzon alone, there were over 70 airstrips that would offer new refueling and rearming stops for Allied aircraft.[23] The seizure of the new airfields also brought the land-based aviation closer to the current fighting. By 23 January 1945, the United States reached Clark Air Field near Manilla. MacArthur's troops would soon make multiple landings throughout the entire archipelago. "He (MacArthur) undoubtedly wished to be remembered as the liberator of all the islands and to fully redeem his pledge that he would return."[24]

Nimitz's Push to the Mainland

The United States needed to either accept thousands more deaths or come up with an alternate plan for Japanese capitulation. The US bomber generals touted strategic bombing as a way to destroy the Japanese war-making industry and its will to fight. One issue was that the bombers' range prevented their reaching the mainland. Boeing introduced the B-29 in 1944 with a greater range than previous bombers. The extended range helped the United States inch closer to the mainland, but without long-range fighter escort, the bombers were vulnerable.[25]

The bomber sorties needed to originate from a closer airfield. Once the US controlled the Mariana Islands, the military decided to move bombers forward and launch strikes from the new locale. This development placed the bombers well within the range of the Japanese mainland and allowed for more sustained strikes.[26] The bombing

---

[23] Griffith, 202.
[24] Spector, *Eagle Against the Sun*, 527.
[25] Spector, 279.
[26] Spector, 279.

missions continued launching from several airfields to target the industrial capacity and then shifted to fire-bombing cities in Japan. Launching aircraft from closer range was effective, but the Marianas were 1,500 miles away, meaning that fighter aircraft could not escort the bombers into the targets. If Nimitz could overtake a closer airfield, like Iwo Jima, it would accommodate the necessity of a closer launching field. Then the P-51 Mustangs could escort the bombers in and out of the bombing raids, improving the success rates.[27]

On 19 February 1945, Marines and the Navy stormed Iwo Jima.[28] Nimitz and his men traversed, fought, and gained 3,200 miles since the beginning of the war, now they were only 800 miles away from the Japanese mainland. Iwo Jima was the only island in the Nanpo Shoto chain that had passable landing beaches and terrain suitable to build airfields.[29] It took one day to secure the beachhead on Iwo Jima but an additional two weeks to secure the airfields on the island.[30] As fighting continued on the island, US aircraft began to use the airfields for emergency diverts, refueling, or rearmament options. The long bloody battle proved costly for the victorious Americans. The Marines' death toll was 6,821 and close to 20,000 injuries.[31] In an effort to stave off further assault, Japan planned to show the Americans that an invasion of the homeland was more than the Americans could accept.

The next closest island was Okinawa and would place the US bombers within 350 miles of the Japanese mainland.[32] Admiral Nimitz launched a massive attack on Okinawa in April of 1945. Bombardment of the island cleared the way for an amphibious landing by the Marines.

---

[27] "506th Fighter Group Captain Abner Aust: 506th Fighter Group, 457 Fighter Squadron, 458 Fighter Squadron, 462 Fighter Squadron Lawrence Smith 472601," accessed February 23, 2019, http://www.506thfightergroup.org/mustangsofiwo.asp.
[28] Spector, *Eagle Against the Sun*, 499.
[29] Spector, 494.
[30] Spector, 500.
[31] Spector, 502.
[32] Spector, 532.

The boats landed and initially met minimal enemy fighting, but this quickly changed. The battle for Okinawa lasted until 21 June 1945.[33] Over 70,000 Japanese military members perished while the United States lost 12,000 troops.[34] The Allies secured Okinawa and, once again, offered a closer island to launch aircraft and stage troops.

The next step was the mainland invasion. The Allies understood the invasion of the mainland would prove to be deadly. The United States searched for a way to show the Japanese that the attacks would only increase. President Truman approved the US military to drop the first atomic weapon on the enemy on 6 August 1945. The Japanese refused to surrender, so the United States dropped a second atomic weapon on Nagasaki on 9 August 1945. The Allies owned airstrips close enough to the mainland that they could continue massive bombardment raids on Japan. The pivotal nuclear and conventional strikes on Japan brought about the ultimate defeat of Japan, and the United States accepted the Japanese unconditional surrender on August 15, 1945.

Island-Hopping Campaign

The above overview of the Pacific campaign provides an important backdrop and primer to the specifics of the island-hopping campaign within it. The main objective in the Pacific was to roll the Japanese back and reach Japan's mainland. Admiral Nimitz used large fleets of ships to move from one cluster of islands to another. The availability of transportation by ship for supplies, men, and aircraft provided him with the flexibility that General MacArthur did not possess. General MacArthur's resources, number of transportation assets, and geographical context played roles in his decision to approach the

[33] Spector, 540.
[34] Spector, 540.

Japanese mainland by hopping from one island to another, strategically bypassing heavily defended islands.

The Navy carriers could launch and recover their own air power, but the Army Air Corps needed to locate, overtake, or build its own airfields in the southwest Pacific. One reason that MacArthur wanted a two-pronged route of travel around the Japanese military at Rabaul was to secure airfields around it in order to keep bombers within range of fighter escorts. Airfields on Bougainville and Vella Lavella ensured logistics could flow to MacArthur's troops while also providing launch and recovery operations for attacks on Rabaul.[35] The theme of seizing or building new airfields would continue throughout MacArthur's time in the southwest Pacific.

General MacArthur needed airfields to launch aircraft that would protect his amphibious landing forces on the ground. The dynamic nature of the enemy's strength on a given island was of the utmost importance to MacArthur's decisions regarding which island to take next. After Operation Cartwheel, MacArthur secured Rabaul and looked to the Philippines. Some within the Joint Chiefs of Staff began to wonder if the United States should skip the entire Philippine island chain, but MacArthur knew the importance of securing strategic islands within the chain, not only for an obligation to the Filipino people but also for airfields.[36] "Leyte promised airfield sites that General MacArthur needed to continue executing his amphibious operations under cover of landbased aircraft, but the promise almost went unfulfilled."[37] Challenges stemming from movement jungle locations continued.

---

[35] Spector, 247.
[36] Bernard C. Nalty, John F. Shiner, and George M. Watson, *With Courage: The U.S. Army Air Forces in World War II*, ed. Alfred M. Beck (Washington, DC: Air Force History & Museums Program, 1994), 285.
[37] Nalty, Shiner, and Watson, 285.

Logistical ships and aircraft needed a place to land, dock, or potentially airdrop supplies.

Aviation engineers were responsible for building the airfields that would allow supplies to flow. The engineers battled against heavy rains, which made drainage an important aspect when constructing the airfields. A lengthy delay caused by monsoons occurred "at Tacloban, where aviation engineers serving as part of the theater engineering force laid pierced steel matting to extend the runways built by the Japanese."[38] Airfield construction and logistical supply flows were not the only concern in the dynamic island-hopping, but aircraft maintenance also proved troublesome.

Aircraft from the Army Air Corps and Navy supported operations on land or at sea, but a lack of main operating bases brought about obstacles to refueling, rearming, and maintaining these warplanes. Aircraft sorties that originated on an aircraft carrier did not mean that the plane would return to a safe and intact ship. Even if the carrier was intact, it could be locked in a deadly fight against other ships and be maneuvering too violently for the aircraft to safely land.[39] Displaced aircraft needed a place to land, fuel, and rearm to return to the fight. The airfields that MacArthur's troops were opening acted as a catchall for the displaced aircraft. The Army maintainers and ordnancemen were now required to fix and rearm unfamiliar aircraft.[40]

Moving from one airfield to another to set up an operational outpost meant that mechanics, their tools, and supplies had to move also. Compared to WWI and interwar aircraft, each WWII aircraft required more mechanics for normal operations. "In the 1930s, one mechanic could perform almost every job on any aircraft, but this was

[38] Nalty, Shiner, and Watson, 285.
[39] Nalty, Shiner, and Watson, 286.
[40] Nalty, Shiner, and Watson, 286.

not so during World War II."[41] For example, each B-29 required a team of 85 personnel to fly and maintain the aircraft, of which 20 were maintainers.[42] General Henry "Hap" Arnold, commanding general of the Army Air Forces, boasted "a global Air Force must have adequate bases, a continual flow of parts and supplies, and a fool-proof system of rapid-fire maintenance."[43]

To facilitate more mobile maintenance and repair operations, the AAF created Air Force Services Command, which devised streamlined maintenance service units. One such unit landed in Saipan five days after the initial US landing, and within three weeks the team built fully operational maintenance servicing facilities.[44] If one of the island-based repair facilities or supply storage was taken out, to deal with such a scenario the United States formed aircraft repair ships. The ships contained a stock of 137,000 parts for the B-29 alone and housed aircraft mechanics to perform almost any job necessary to rehabilitate a plane.[45] The Allies learned and created new mobilization and sustainment concepts throughout the Pacific theater.

The geography and large number of islands that Japan controlled forced the United States to implement a new way of war. Island-hopping provided an answer to logistical quandary but was not without its own set of difficulties. General Arnold stated, "Island-hopping accelerates progress toward Tokyo. Our air power destroys or renders ineffective the enemy's air strength preparatory to landings or so that enemy air bases can be successfully by-passed."[46]

---

[41] Nalty, Shiner, and Watson, 175.
[42] Henry Arnold, *Second Report of the Commanding Generaleral of the Army Air Forces to the Secretary of War: February 27, 1945* (U.S. Government Printing Office, 1945), 73. The Army Air Corps relinquished control of the air arm to the Army Air Forces in March 1942 under General Henry "Hap" Arnold, per Executive Order 9082.
[43] Arnold, 72.
[44] Arnold, 72.
[45] Arnold, 72.
[46] Arnold, 58.

The next two chapters take a closer look at the logistics and aircraft maintenance support required in the Pacific during the island-hopping campaign. Each chapter utilizes two categories, mobilization and sustainment, to identify contributory concepts and factors to the logistical and aircraft maintenance efforts in the Pacific.

Chapter 3

Logistical Analysis

Logistical planning and execution are vital to any war effort, and some military theorists even argue for the "equivalent theory of logistics," which asserts that the three driving elements to a war effort are strategy, tactics, and logistics.[1] The Allied victory in the Pacific stemmed from a variety of factors but the logistical feat carried out by the United States and its Allies remains one of the most impressive. The Army Service Forces' final report to the Deputy Secretary of War in 1947 stated that "World War II was a war of logistics. Never before had a war been waged on such varied and widespread fronts."[2] The United States and Allied logistical efforts are worth analyzing to understand what inherent difficulties the militaries dealt with and how they overcame the impediments.[3]

This chapter will use two categories to analyze the logistical prowess exhibited by the Allies from 1941 through the end of the war in the Pacific theater. Each section will use the historical context to identify underlying problems and then discuss how the United States attempted to solve those problems. The two categories, mobilization and sustainment, are temporally-based and offer two separate timeframes to identify critical areas. The section on mobilization discusses the issues caused by the tyranny of distance and the need for a rapid build-up. The second temporal category analyzes how the United States continued to

---

[1] Christopher Papararone, "Army Logistician," *Army Logistician* PB 700-95-1 (1995): 12.
[2] US Army Center for Military History, *Logistics in World War II: Final Report of the Army Service Forces : A Report to the Under Secretary of War and the Chief of Staff by the Director of the Service, Supply, and Procurement Division, War Department Generaleral Staff* (Center of Military History, United States Army, 1947), 32.
[3] O'Brien describes the air and sea integration space as a "super-battlefield" that provided opportunities for the United States and Japan to attack the adversaries' pre-production (resources), production (factories), and post-production (shipping). Phillips Payson O'Brien, *How the War Was Won* (Cambridge University Press, 2015), 5.

sustain the war efforts in the Pacific while addressing the lack of logistical infrastructure, i.e., ports, storage, and airfields.

Mobilization

The distance that supplies had to travel from the United States to the theater of war and the need for rapid buildup if a war ignited defined the logistics of the mobilization phase from the late 1930s through 1942. In the case of the Pacific, the considerable distance from the United States to the southwest Pacific and the need for quick movements created complications. These two contextual constraints, distance and the requirement for speed, continued to complicate the Allies' logistical plan throughout the war but specifically drove the Allies to identify solutions in the build-up phase.

Although neither President Roosevelt nor the United States Congress had declared war on any country early in 1941, the military was maneuvering to preposition assets. The prepositioned assets were not the only pre-war mobilization effort; the Lend-Lease Act in July 1941 also contributed to a logistical plan if the United States were to enter the war. This section will analyze the effects of prepositioned assets, the Lend-Lease Act, and the utilization of local resources and manufacturing on the supply and transportation of war-making capacity in the Pacific.

Access to Supplies

"Time is the most precious element in the logistic preparations for security. Measures must be prepared in advance for the all-out logistic mobilization that must be completed between the time when danger threatens and the time that war actually strikes."[4] The United States understood that supplying a war halfway across the world would prove almost impossible without a mobilization plan. Beginning in 1922, the

[4] US Army Center for Military History, *Logistics in World War II*, 246.

Navy and the War Department started a series of mobilization plans through an Army and Navy Munitions Board.[5] Over several iterations and a transfer to a new civilian agency called the Office of Production Management in January 1941, the United States took steps to mobilize the nation's various industries. Other agencies, such as the Office of the Petroleum Coordinator, which synchronized efforts from refining to transporting oil, also stood up to assist in mobilization.[6] Each of these mobilization efforts focused on the United States' ability to bring supplies to a future theater of war.

Before the United States entered World War II, the principal overseas bases were the Philippines, Hawaii, Panama, and Puerto Rico.[7] These locations housed a small number of troops and supplies in the interwar years. Troops rotated through these locations, building relationships with the local population and relying on them for food supply. These outposts were ill-equipped to defend themselves. For example, Wake Island in 1941 only had 12 fighter aircraft and 18 antiaircraft guns, of which six were from WWI.[8] Modern materiel did not reach the Philippines until July of 1941 and by 7 December 1941 the United States only had 250 aircraft on the Philippine islands.

The Philippines and other smaller troop garrisons not only lacked defensive necessities but initial shipments of food and standard supplies transited the Pacific at slow rates. Records show that the average time for a supply ship to make a round trip from the United States to a port in the Pacific, unload the supplies, and return to its originating port was 115 days. Troop-carrying vessels could make the same trip in around 69 days, which meant that the troops arrived at a faster rate than the

[5] US Army Center for Military History, 4.
[6] US Army Center for Military History, 4.
[7] US Army Center for Military History, 8.
[8] US Army Center for Military History, 10.

resupply ships.[9] The swift and massive troop build-ups after Pearl Harbor exacerbated the issue, which drove the Army's Quartermaster General in Washington to search for better ways to feed and supply the troops throughout the Pacific. By January 1942, the United States understood that it needed to cut the amount of US-originated food and equipment to save valuable time.

Lend-Lease Act

Until 8 December 1941, the United States was still a neutral country, and Congress had passed four Neutrality Acts to preclude America's involvement. President Roosevelt continually received messages from Winston Churchill asking for supplies, ships, and other aid. Congress's Neutrality Act had a subsection that allowed the United States to sell goods to countries engaged in war if they paid in cash. President Roosevelt used this to send supplies to Europe until Britain was bankrupt and could not afford enough supplies. Subsequently, the President created a plan called the Lend-Lease Act, which would lend "strategic partners," war-making materials, ships, and tanks. The Lend-Lease plan specified that after the war was over the countries would return the borrowed goods. On 11 March 1941, Congress passed the law and supplies and funds flowed from the United States across the world.[10] Mr. Winston Churchill, England's Prime Minister, called the Lend-Lease Act "the most unsordid act in the whole of recorded history."[11]

To reduce the cost and time to ship supplies to SWPA, the British Commonwealth, mainly Australia, created the Reverse Lend-Lease, which supplied the United States with food, natural resources, and

---

[9] Robert W. Coakley and Richard M. Leighton, *Global Logistics and Strategy, 1943-1945* (Center of Military History, United States Army, 1986), 725.
[10] O. Schreiber, "Tenth Anniversary of Lend-Lease: How America Gave Aid to Her Allies," *The Australian Quarterly* 23, no. 3 (1951): 64, https://doi.org/10.2307/20633372.
[11] Schreiber, 64.

manufacturing capacity. The overall contribution from Allied nations to the United States was $8 billion, with 90 percent coming from the British Commonwealth.[12] Australia alone gave $888 million to the United States in food and supplies.[13]

Reverse Lend-Lease was essential to the logistical mobilization and sustainment in the Pacific theater and cut the time of transportation to a minimum. The most substantial buildup of forces and supplies came in the summer and fall of 1942, and General MacArthur wanted a strategic location to shorten supply lines and to establish major bases on the coast for logistical support of future operations. The United States objective in the New Guinea campaign met both objectives.[14] The Reverse Lend-Lease created a structure to leverage local resources and manufacturing capabilities.

Local Resources and Manufacturing

The United States shortened the supply chain by leveraging the resources throughout the Pacific. Some countries had little resources to offer but "Australia and New Zealand, however, were able to fill a large part of the Army's requirements."[15] Even countries with lower amounts of resources assisted when able. For example, lumber usage rose to an alarming rate as MacArthur's men continuously moved to new islands. Receiving shipments of wood from the United States was a slow process. The United States partnered with New Guinea and created a new timber company stood up called the Thick and Thin Lumber Company to cut the time from the request for materials to delivery.[16]

---

[12] Schreiber, 66.
[13] Schreiber, 67. The US lent approximately $50 billion to its allies, mainly Britain and Russia, in the Lend-Lease Act. The Reverse Lend-Lease was part of the British Commonwealth, Australia, reciprocating the US funds.
[14] US Army Center for Military History, *Logistics in World War II*, 49.
[15] James Raymond Masterson, *U.S. Army Transportation in the Southwest Pacific Area, 1941-1947* (Transportation Unit, Historical Division, U.S. Army, 1949), 253.
[16] Henry Arnold, *Report of the Commanding Generaleral of the Army Air Forces to the Secretary of War* (U.S. Government Printing Office, 1944), 22.

The United States military also sought to shorten the supply chain by using manufacturing capabilities in the local areas. For example, when military leaders understood that fighter aircraft with a more extended range could protect airfields, ships, and escort bombers more effectively, they set out to create drop tanks. Typically, a similar requirement traveled up to headquarters for testing, procurement, and shipping. Instead, General MacArthur took it into his own hands and contracted with the Australian Ford motor company to engineer and produce drop tanks.[17] Utilization of manufacturing capabilities within the region enabled rapid deployment for capabilities, but more importantly, shortened the supply chain.

The United States eased the burden brought on by a lack of access to supplies by coordinating prepositioned assets and leveraging resources and manufacturing of allies through the Reverse Lend-Lease. When General MacArthur began his island-hopping campaign in 1942, the ability to procure supplies from neighboring nations provided flexibility and a continuous flow of goods, yet a new issue arose in sustainment logistics: a lack of logistical infrastructure. The next section analyzes these issues beginning with the transition from pre-war buildup to conflict and continuing through the ultimate victory over Japan.

Sustainment

The mobilization effort in the Pacific suffered the tyranny of distance, but prepositioned assets and the effects of Reverse Lend-Lease created sustainable options for the United States military. Once the materiel moved into theater and MacArthur engaged in Operation Cartwheel (the island-hopping campaign), sustainment of the war effort presented a new dilemma. In terms of sustainment, the most significant

[17] Eric M. Bergerud, *Fire in the Sky: The Air War in the South Pacific* (Westview Press, 2000), 269.

obstacle was a lack of logistical infrastructure like ports, supply storage, and airfields. Ships transported the vast majority of supplies but "during 1942 the bulk of available shipping was utilized in the Atlantic."[18] The ships that were available to the Pacific theater wasted valuable time waiting for open ports and an inefficient unloading prioritization exacerbated the problem. This section analyzes two sustainment efforts in the Pacific. First, it examines large bulk shipments into the theater and second, it analyzes logistical efforts to supply movement between islands. A lack of infrastructure hampered both logistical efforts.

Obstacles in Large Port Operations

One significant issue was the lack of large ports and inefficient unloading procedures only intensified the problem. "Because of the distances in the Pacific, tremendous quantities of shipping were required for relatively small forces."[19] The long 115-day transport time on supplies drove scarcity of certain items, especially early in the campaign before supply requirement studies. Timeliness of delivery worsened when large ships arrived at a location with inadequate offloading capabilities. The ship anchored off-shore and a small shuttling vessel would dock alongside the transport vessel to unload supplies.[20] The high demand for certain supplies meant the shuttle vessels prioritized the unloading of scarce goods first and then moved to another docked ship to offload other vital supplies. Leaving the rest of the supplies onboard meant that ships could wait for weeks in port before the less scarce supplies were unloaded. A lack of logistical planning early in the war and inadequate offloading capabilities contributed to delays like this.

The piecemeal unloading was a symptom of a lack of shipping prioritization between the Army and Navy. "The Director of Operations of

[18] US Army Center for Military History, *Logistics in World War II*, 49.
[19] US Army Center for Military History, 49.
[20] US Army Center for Military History, 49.

the Army Services Forces went to the Pacific to investigate this problem. His recommendations resulted in the establishment of a Joint Logistics Staff and phased shipping to the South Pacific Theater."[21] The Joint Logistics Staff created a prioritization system to expedite shipping for the entire joint force. Additionally, the South Pacific commander created the Joint Logistics Board. The Board studied the delays and enacted a new priority unloading system that would phase shipments and allow time for the download of all goods to ensure that transportation vessels were not sitting idle in ports.[22] After decreasing delays for ships arriving in large ports, the Pacific leadership turned its attention to resupplying troops as General MacArthur's forces moved from one island to another.

Sustaining a Moving Target

The inherent flexibility offered by the island-hopping campaign centered on the ability to gain operationally advantageous territory that would then enable future operations. A lack of island-based logistical infrastructure like roads, airfields, and supply storage plagued the AAF throughout the campaign. Each hop offered the ability to skip over heavily defended locations and slowly close in on Japanese strongholds to cut the enemy's supply lines. "Such operations were dependent for their success upon immediate logistic support and the rapid build-up of supplies and equipment in the new areas."[23]

To meet the needs of amphibious landing forces, the Army created amphibian engineers. These specially trained engineers were some of the first to land on a beach, set up beach markers, unload heavy equipment, clear the beaches, and lay metal-mesh surfaces to provide traction for

[21] US Army Center for Military History, 49.
[22] US Army Center for Military History, 49–50.
[23] US Army Center for Military History, 50.

vehicles.[24] On 28 and 29 of April 1943, the 2d Engineer Amphibian Brigade (EAB) participated in a dress rehearsal in Australia before a forward deployment in support of General MacArthur. After a successful exercise the 7th Amphibious Force, 7th Fleet gained operational control of the EABs.[25] These EABs provided the initial supply flow and infrastructure to support future supply shipments.

Once American troops performed the amphibious landing and secured a beachhead, the EABs searched for geographical landscapes conducive to the creation of airstrips and ports. "Almost without exception these areas were trackless jungles, and all facilities, including roads, trails, and airfields, had to be constructed."[26] Although maritime shipping transported a bulk of supplies into the theater, airlift and airdrop provided the ability to move supplies within the theater. Aviation engineers surveyed potential airfield sites or previously existing airfields to estimate the labor and supplies necessary to transform the land into a logistical hub. The duration of construction or repairs varied depending on the state of the land, but the sooner that runways became operational meant that C-47 transport aircraft could land with additional supplies.[27] Although the EABs mitigated the issues posed by the lack of airfields, roads, and supply offloading sites, they did not solve all the AAF's problems. Even after the Army introduced EABs, a lack of storage continued to plague the island-hopping effort.

"Not so encouraging were the recurring difficulties of procurement from the United States, inadequate storage and the chronic shortages of

---

[24] *Engineers of the Southwest Pacific: 1941-1945 ... By the Office of the Chief Engineer, Generaleral Headquarters, Army Forces, Pacific .... Amphibian Engineer Operations* (U.S. Government Printing Office, 1959), 44–48.
[25] *Engineers of the Southwest Pacific*, 52.
[26] US Army Center for Military History, *Logistics in World War II*, 50.
[27] *Engineers of the Southwest Pacific 1941-1945...: Airfield and Base Development....* (U.S. Government Printing Office, 1951), 344.

shipping and port facilities."[28] Members of a given unit would storm a beach and push into unforgiving terrain wrought with enemy fighters. The need to remain highly maneuverable required each troop to carry the minimum survival necessities and the quartermasters were responsible for procuring other supplies on demand. When a base was established, the storage capacity grew, but due to its constant movement, it was ill-advised to bring all supplies ashore. The army solved the issue by taking 17 dry barges intended to carry bauxite and transforming them into floating storehouses capable of resupplying several island locations at one time.[29] As General MacArthur's troops progressed forward, the supply ships moved simultaneously to keep the supply chain as short as possible. These floating supply ships not only answered part of the storage issue but also offered flexibility to fuel multiple engagements at one time.

The ability to adapt to a continually changing context offers more solutions to a given problem. The expanse of the Pacific, lack of substantial ports for resupply, and need to fight an enemy entrenched on multiple island chains made logistical flexibility a necessity. In short, the lack of ports and logistical infrastructure in the SWPA continually caused difficulties in supplying the war. The United States' decisions to procure local resources and labor, use EABs to build logistical infrastructure, and create floating supply ships alleviated the impact of an immature logistical infrastructure.

Summary

The purpose of this chapter was to identify critical areas within the logistical apparatus in two categories. The mobilization phase suffered

---

[28] *Engineers of the Southwest Pacific 1941-1945* (U.S. Government Printing Office, 1947), 200.
[29] Frederic Chapin Lane, *Ships for Victory: A History of Shipbuilding Under the U.S. Maritime Commission in World War II* (JHU Press, 2001), 634.

from the vast distance between the United States and the Pacific theater of operations and the requirement for quick movements. The mobilization for the war effort in the Pacific was a slow process that took 18 months to achieve full capacity due to lack of logistical infrastructure. The prepositioned assets, Reverse Lend-Lease, and utilization of local resources and manufacturing boosted the logistical flow throughout the region.

Once mobilized, sustainment of the forces became a top priority for military leadership. In the early stages, the lack of major ports and adequate offloading capabilities made inter- and intra-theater transportation of goods difficult. Delays due to prioritization flaws and inefficient unloading operations made the issue more pronounced. The Army identified solutions to some of the supply dilemmas by building or upgrading logistical infrastructure. The creation of amphibious engineers to storm the beaches with infantry soldiers and organize supply flows as needed proved useful throughout the campaign.

The engineer amphibian brigades partially solved the lack of island-based infrastructure, but they did not solve the lack of storage. To expand the storage capacity while adding flexibility, the United States created floating supply barges that moved along with the Army units as they hopped from island to island. Allied forces in the Pacific displayed adaptability to combat the lack of logistical infrastructure. The next chapter utilizes the same categories of mobilization and sustainment to analyze aircraft maintenance in the Pacific.

Chapter 4

Aircraft Maintenance Analysis

During testimony to a Congressional committee in January 1939, General Arnold stated, "An Air Force is a balanced compound of three essential ingredients—airplanes, combat and maintenance crews, and air bases."[1] Maintenance of aircraft flying into and out of combat on a diverse set of missions was center-stage for General Arnold even before the hostilities of World War II began. Aircraft changed rapidly in the interwar years, which created new hurdles for mechanics on the flight line. The Army Air Corps needed to realign training, adapt phased maintenance, and understand sustainment methods in case events forced it into war. After the war started, the importance of aircraft maintenance only grew. "The greatly increased rate of operations, the high incidence of battle damage, and the growing complexity of the military airplane during World War II made maintenance one of the most vital functions in the waging of the air war."[2]

This chapter analyzes aircraft maintenance throughout the mobilization and sustainment efforts which enabled air power in the Pacific. It begins with an examination of mobilization, using the build-up timeframe to identify problems encountered and discuss solutions. The United States had to grow and deploy the maintainer force rapidly, which took military maintainers away from depots in the United States and required a new type of continuation training to keep maintainers apprised of new aircraft developments. Next, the sustainment section analyzes the United States' struggle to supply and store aircraft parts in the Pacific theater. The Army's reorganization and creation of the Army

[1] Office of Air Force History, *Men and Planes*, vol. 6, The Army Air Forces in World War II (DIANE Publishing, n.d.), 119.
[2] Office of Air Force History, 6:388.

Services Command offered a focal point to streamline the aircraft parts supply chain. This chapter utilizes the mobilization and sustainment categories to identify critical problems that directly contributed to success or failures in the Pacific and concludes with a summary of the primary lessons.

Mobilization

The military aviation complex transformed dramatically between World War I and II. The 1930s brought about new types of aircraft materials. Fabric wings gave way to metal-covered wood and then to all-metal bodies. Communications equipment and flight instruments grew more complex. Overall, aircraft had more moving parts to inspect, repair, and operate. To increase the reliability rate of aircraft, the Army Air Corps implemented preventive maintenance in the 1930s.[3] Preventive maintenance included more inspections at regular intervals. Maintainers at first only performed daily pre-flight inspections, but following the call for preventing future maintenance activities, maintainers added additional inspections and maintenance actions at regular flying hours increments (20-hour, 40-hour, 80-hour inspections).[4]

The additional inspections increased the workload, and the growing possibility of the United States entering the war forced the Army Air Forces to grow its maintenance populations rapidly. The overarching issue during the mobilization phase was an immediate need to train and deploy maintainers while introducing new aircraft directly to the theater. Mechanics that worked in depots deployed and left gaps in depot personnel levels that civilians filled. Additionally, even though the AAF

[3] AAF Historical Office, "The Maintenance of Army Aircraft in the United States, 1939-1945" (Headquarters Army Air Forces, August 1946), 7, Air Force Historical Research Agency.
[4] AAF Historical Office, 5.

adapted its initial training program, rapidly changing aircraft technology created a requirement for continuation training for deployed personnel. The following two sections explain how the AAF handled the immediate need for exponential growth and training of maintainers and then how the deployment of US-based maintainers affected depot-level maintenance gaps.

Training Pipelines

From 1938 to 1939, the Air Force graduated 900 maintainers from the training pipeline.[5] Training 900 maintainers per year was sufficient for the 2,422 aircraft that the Army Air Forces operated at the time, but the inventory skyrocketed to 79,000 aircraft by 1944.[6] Training enough maintainers became a top priority for the AAF leadership. The interwar mechanic training model was designed around a 38-week course that taught general mechanics, tool operations, and provided some hands-on practice.[7] The 38-week course produced a quality "general mechanic" that could work on any aircraft in the inventory. Any specialization came on the job with a more experienced maintainer.

The challenges that the previous training model struggled to meet were the production numbers and learning complex new aircraft entering service. In order to overcome these challenges, the AAF slashed the training course from 266 days to just 112 days solely focused on a specific aircraft.[8] The new training produced a more qualified mechanic but took away any flexibility to work on aircraft outside of the prescribed specialization. Previously, a generalist mechanic could work on any aircraft, but now the extreme specialization caused issues in the field.

---

[5] Office of Air Force History, *The Army Air Forces in World War II, Volume Six*, 6:6.
[6] AAF Historical Office, "The Maintenance of Army Aircraft in the United States, 1939-1945," 8.
[7] Office of Air Force History, *The Army Air Forces in World War II, Volume Six*, 6:631.
[8] Office of Air Force History, 6:631.

Army Air Forces leadership recognized the new inflexibility and created a training course compromise which consisted of a 76-day general aircraft mechanics course followed by a 36-day aircraft specific course.[9] This solution met several needs, including faster maintainer production, generalist skills, and the ability to switch airframes with a swift 36-day transition course. Between 1939 and 1945, the AAF trained 700,000 maintainers.[10]

The growing complexity of aircraft, types of aircraft, and complications from moving island to island continued to present training challenges for maintainers. The problems, which stemmed from a need for rapid growth in the maintainer force, were exacerbated by the dilemma of generalist mechanics versus highly specialized ones. The delicate balance required to produce a mechanic that had operational viability yet attained practical knowledge across specializations and platforms created inherent flexibility within the maintenance corps.

The changes that AAF leaders made to initial training produced more maintainers with general knowledge. Establishing basic knowledge followed by specialized and on-the-job training created more adaptable maintainers. This training model allowed for the flexible deployment of maintainers to locations with multiple aircraft, which enabled mechanics to work on more than one platform. Aircraft mechanics employed the mechanical knowledge for applications that seemed impossible. In 1944, General Arnold praised a maintenance crew that arrived at a cargo aircraft crash site in a jungle and dismantled the entire aircraft and loaded it on to a trailer to transport back to base. After the wreckage arrived on base, "the plane was made ready to fly in a matter of hours."[11] Another common occurrence was mating a nose section of a wrecked B-

[9] Office of Air Force History, 6:631.
[10] Office of Air Force History, 6:630.
[11] Arnold, *Report of the Commanding General of the Army Air Forces to the Secretary of War*, 23.

17 to the intact tail section of another salvaged aircraft.[12] Without the general mechanical training and applicability of the on the job training received the adaptability of aircraft maintenance suffered. The initial training provided the necessary flexibility, but the AAF also needed a way to keep training the maintainers in the field.

Continuation Training

Manufacturing new aircraft or making modifications to existing ones created a need for updated training within the maintenance community. Mechanics needed up-to-date information on aircraft arriving from factories, but manning levels did not allow maintainers to return to home for additional training. To combat the issue, Air Service Command created mobile training units (MTUs). These units traveled to teach refresher training and the latest changes to procedures. This mobile design brought the school to the student.[13] The MTUs were so productive and valuable that by the end of the war, 24 units deployed overseas with five en route to contingency theaters, and an overwhelming 100 units operating in the United States.[14]

Aircraft mechanics in the southwest Pacific provided air power with operational flexibility previously not tested. That adaptability, in combat situations, on islands with minimal infrastructure, and in situations never seen before, grew from the training programs administered to the maintenance crews. The general mechanical knowledge laid a groundwork for the mechanics to adapt from and for the MTUs to build on with more specific and relevant information. Senior leaders found a successful training mindset that struck a balance between general knowledge and specialization but the newly trained and deployed

[12] Arnold, 22.
[13] Office of Air Force History, *The Army Air Forces in World War II, Volume Six*, 6:636.
[14] Office of Air Force History, 6:636.

mechanics left personnel shortages at maintenance depots around the world.

Mobilization efforts brought obstacles like the need for rapid and exponential growth in the maintainer force and the requirement to continuously train mechanics in the field. The United States answered by creating new models for initial and continuation training that balanced the value of general knowledge and specialization. That balance and training the force were not the only challenges that the military and industry faced with regards to aviation maintenance; parts and supply also proved to be a weak area especially in the sustainment phase.

Sustainment

Mobilization created a need for growth in the maintainer force which brought changes in training to meet the demand. As sustainment of assets in theater rose in priority, a new set of challenges emerged, namely the difficulty in accessing parts. The United States struggled to plan for and supply the Pacific theater with proper levels of aircraft parts. To rectify the situation, the Army reorganized and created the Army Service Command to analyze requirements, interface with manufacturers, order parts and find solutions to a lack of traditional parts storage.

Theater Access to Parts

The geography in the southwest Pacific and distance from manufacturers to maintainers, along with other issues, worsened the lack of access to parts. At the start of the war, two issues contributed to the aircraft parts shortage problem: the contract to buy aircraft without spare parts and a lack of historical data with which to better estimate future needs. First, the Army Air Forces purchased aircraft as a whole

plane.[15] In other words, spare parts were not purchased to follow the plane into combat, which immediately created a shortage. After the realization that manufacturers and the military needed to forecast numbers of necessary spare parts, the aircraft manufacturers estimated and supplied parts in packages, called "pack-ups."[16] These large containers housed parts that the manufacturer estimated would be needed in combat. Although this alleviated the initial problem of complete lack of spare parts, the AAF faced a second challenge. Specifically, manufacturers did not have any historical numbers to base their estimates, which led to misguided parts manufacturing and shortages in vital components. Early on, manufacturers shipped spare parts based on anticipated consumption rates.[17] This action led manufacturers to send excess parts on hand rather than focusing on fixing the vital spare parts supply.

The AAF noted the supply chain issue, took the process out of the manufacturers' hands, and created an internal organization, Air Services Command (ASC), to analyze necessary amounts of parts, order the parts, and organize the delivery.[18] "The ASC developed supply tables which were lists of the maintenance and overhaul parts (items like gaskets, landing gear, wing tips) and supplies (sheet metal, rope, solvents, etc.) required for maintenance. There were many such tables, each designed to meet the requirements for maintenance of aircraft and equipment under a variety of circumstances at the several echelons of maintenance."[19] After each iteration in the ordering process, the ASC amended its tables and achieved higher accuracy in predicting actual consumption rates.

---

[15] AAF Historical Office, "The Maintenance of Army Aircraft in the United States, 1939-1945," xx–xxii.
[16] AAF Historical Office, 33–34.
[17] Office of Air Force History, *The Army Air Forces in World War II, Volume Six*, 6:383.
[18] Office of Air Force History, 6:384.
[19] Office of Air Force History, 6:385.

Local Access to Parts and Depots

The parts-storage issue became more critical on each island with fewer storage facilities and the likely need to rapidly pack up and move. Moreover, on-island maintenance capabilities could not fix an aircraft that required depot-level maintenance. To answer both issues, the United States created aircraft repair ships that also acted as floating depots. For example, a B-29 depot maintenance ship carried "mechanics, propeller specialists, sheet metal workers, and other skilled craftsmen who can be moved to any spot where they are needed."[20] The floating depot carried parts to assist with the lack of storage options and the inflexibility of moving land-based repair facilities every few months. The B-29 depot-ship carried 137,000 spare parts to ensure the aircraft continued the fight with as little downtime as possible.

Floating depots alleviated an issue in the storage capacity and produced a built-in transportation mechanism for parts, but land-based crews were still required to perform the first and second echelons of aircraft maintenance.[21] Daily inspections, fueling, rearming, and a majority of repairs happened at each island location. After a plane completed its daily missions, maintainers rushed to perform any repairs on the spot. Some aircraft returned with little to no damage, while others returned missing an engine and littered with bullets holes. Conducting maintenance on aircraft while in combat presented unforeseen challenges like launching aircraft from new airfields or quickly packing equipment and parts for an impending hop to a new island.

In the southwest Pacific, moving from one operating location to another was common, but maintainers had to launch aircraft no matter

---

[20] Arnold, *Second Report of the Commanding Generaleral of the Army Air Forces to the Secretary of War*, 72.
[21] See Glossary for maintenance levels.

the location or stability of operations. When planning an amphibious landing, if leaders expected or needed to make quick use of an airfield for flight operations, the maintainers went ashore immediately after the infantrymen.[22] Gaining ground, toward an airfield or conducive terrain for aircraft operations, could take weeks or just hours, which required maintainers to remain ready. Combat units moved at different paces depending on the enemy's resistance, though many times they moved more quickly than maintenance facilities were built.[23] The units protected the airfield as long as possible before their objectives required movement away from the temporary bases.

Movement from one island to the next meant that most heavy maintenance equipment moved by ship and needed shuttle vessels to transport the tools to shore. The landing forces needed to subdue the enemy before transporting machinery on to the island. Many times, equipment remained behind to ensure operations continued at previously settled bases.

General Arnold recalled a trip that took him to a barren atoll in the Pacific where Americans forces hammered a runway in the coral ground. The maintainers and engineers built housing, docks, and maintenance facilities. The mechanics built an engine hoist out of washed up timbers from a wrecked ship. Within just 100 days of Americans first wading ashore, the atoll operated at peak air traffic.[24]

The context of maintaining aircraft on islands with minimal existing infrastructure while in combat created challenges for aircraft sustainment purposes. Low access to critical parts and storage caused a backlog in supply chains that drastically slowed aircraft launch

---

[22] George Churchill Kenney, *Generaleral Kenney Reports: A Personal History of the Pacific War*, USAF Warrior Studies (Washington, D.C: Office of Air Force History, U.S. Air Force, 1987), 398.
[23] Office of Air Force History, *The Army Air Forces in World War II, Volume Six*, 6:385.
[24] Arnold, *Report of the Commanding General of the Army Air Forces to the Secretary of War*, 15.

capabilities. Once leadership identified that manufacturers shipped parts based on rudimentary consumption predictions, Air Services Command took over the process and created data-driven consumption tables based on several variables. When the shortage of parts decreased, ASC answered the lack of storage and depot-level maintenance by creating floating depot and supply ships that maneuvered throughout the theater to provide access to parts of higher echelons of maintenance.

Summary

In the Pacific theater, the Army Air Forces flew over 500,000 sorties from 1941-1945.[25] The aircraft maintenance force played a primary role in the success over the Japanese. The mobilization and sustainment sections provided a path to diagnose several key hurdles the United States faced in the SWPA with regards to aircraft maintenance. The required rapid mobilization of air power capability led to significant shortages of maintainers in-garrison and deployed. The AAF completely redesigned the maintainer training course to increase production. The revamped course also provided a basic general course and a shorter specialization course which amplified the adaptability in the field.

With regard to sustainment, the major challenge facing the Army Air Forces was access to parts. This challenge stemmed from the government's practice of buying airplanes without spare parts and worsened due to a lack of storage, constant movement, and manufacturer-induced supply chain disruptions. The Air Services Command solved the parts-shortages by developing demand-driven consumption rates based on environmental factors. The command also tackled the difficulty of parts storage and distance to stateside depots by creating floating depots with large stockpiles of spare parts.

---

[25] Henry Harley Arnold, *Third Report of the Commanding Generaleral of the Army Air Forces to the Secretary of War* (Superintendent of Documents, 1945), 64.

The following chapter moves away from the World War II case study and explains a current deployment model, referred to as Adaptive Basing. The term Adaptive Basing refers to several operational concepts that are explained in further detail, but potentially resemble the island-hopping campaign in the Pacific theater. After a description of Adaptive Basing, chapter 5 will tie the lessons identified in chapters 3 and 4 to the Adaptive Basing scenario to offer future areas of study.

Chapter 5

Adaptive Basing Strategy and Implications

The term "island-hopping" is fitting for the WWII Pacific scenario, as it encapsulates the necessary tactical and strategic maneuvering required to defeat the Japanese. This dynamic deployment concept is still around due to its inherent flexibility, but it falls under a larger umbrella now called Adaptive Basing. A war in the Pacific would still present many of the challenges that the United States and allies faced in WWII. If we apply these lessons to a contemporary scenario, a fight against China offers a good case study of how we might employ forces. The problem of distance has not changed, and the need to rapidly deploy forces and assets to theater for war remain intrinsic to the Pacific theater's geography.

To complicate the scenario, China continues to employ an anti-access/area denial strategy that threatens islands the United States had previously considered sanctuaries. The US bases located in Japan, Korea, and the Philippines all lie within reach of older Chinese weapon systems, and new weapons like the DF-26 expand the threat rings significantly and threaten additional US bases.[1] The DF-26, for example, is termed the "Guam Killer" since it is considered the first conventional weapon to hold Guam at risk. The new threat ring also includes key areas in India and northern Australia. In an effort to complicate China's operational calculus, the United States is developing a more agile deployment construct.

[1] Sebastien Roblin, "Why China's DF-26 Missile Is a 'Guam' Killer and a Nuclear Killer," Text, The National Interest, November 9, 2018, https://nationalinterest.org/blog/buzz/why-chinas-df-26-missile-guam-killer-and-nuclear-killer-35847.

The 2018 National Defense Strategy (NDS) calls China a strategic competitor and a revisionist power that is "using predatory economics to intimidate its neighbors while militarizing features in the South China Sea."[2] The NDS also points out China's plans to modernize and expand its influence aimed at regional hegemony in the Indo-Pacific region.[3] As the competition continues, the NDS asserts that the United States desires transparency and open dialogue to reach common agreements. One of the goals is to "be strategically predictable, but operationally unpredictable."[4] If relations with the Chinese deteriorate over any number of issues, Adaptive Basing would achieve the operational unpredictability called for in the National Defense Strategy.

This chapter offers a basic overview of Adaptive Basing and gives insights into key factors that are relevant to a scenario in the Pacific. Specifically, this chapter explores issues surrounding distance and rapid redeployment between operational locations. The final section takes the critical issues from the WWII case study and analyzes the common threads in a contemporary scenario.

What is Adaptive Basing?

This section discusses the problem that Adaptive Basing seeks to address and provides information regarding its foundational capabilities. First, it is crucial to lay out the problem that this deployment construct tries to solve. The competitive advantage that the United States has enjoyed since the end of the Cold War is diminishing as China strives for technological and military parity. China's gains increase the risk to US Indo-Pacific bases.[5] To complicate China's strategy, the US military may

[2] Jim Mattis, "Summary of the 2018 National Defense Strategy," n.d., 1.
[3] Mattis, 2.
[4] Mattis, 5.
[5] Maj David Dammeier, Lt Col Meka Toliver, and Capt Logan Smith, "Overcoming a Power Projection Problem," *CE Magazine*, 2016, https://www.afcec.af.mil/News/CE-Online/Article-Display/Article/1004470/overcoming-a-power-projection-problem/.

need to retrograde assets from the larger bases and quickly build out smaller outposts. The Air Force created the Adaptive Basing strategy to complicate an adversary's operational targeting, in this case, China. This construct offers a variety of options, the most important of which, in the context of this study, are untethered operations (UTO), forward arming and refueling points (FARP), and rapid package deployments.

Untethered operations leverage robust basing and partner capabilities to create additional options while hiding or complicating the threat picture for the adversary.[6] They seek "to reduce or even eliminate the need to 'tether' fighter aircraft to MOBs."[7] In more practical terms, this means a specified number of fighter or bomber aircraft would deploy forward along with the required logistical backbone and maintenance personnel. Instead of these combat aircraft relying on large US-owned bases, UTO offers the option operate from recently captured, newly constructed, and partner nations' airfields. The possibility of quick sortie generation in an expanded number of locations offers strategists and operational planners new flexibility.

The use of FARPs to preposition equipment, fuel, and munitions enables forward-bases for UTO and other operational maneuvers. One major challenge posed by continuous movement between austere operating locations is the lack of existing logistics and maintenance support for each specific aircraft. However, "[i]f enough support (fuel, munitions, and maintenance) is prepositioned, then the logistics load can be reduced to the point that a single C-17 (or even a C-130) load can

---

[6] Fuel, munitions, and maintenance personnel travel on the airlift platform for new construction airfields and pre-positioned assets go to established operating locations. This concept is called Rapid Raptor and falls within Agile Combat Employment. From Maj General Charles Brown Jr., Brig General Bradley Spacy, and Capt Charles Glover III, "Untethered Operations: Rapid Mobility and Forward Basing Are Keys to Airpower's Success in the Antiaccess/Area-Denial Environment," *Air and Space Power Journal* 29, no. 3 (2015): 18-21.

[7] Brown Jr., Spacy, and Glover III, 22.

support fighter operations almost indefinitely."[8] Adaptive Basing and the operational concepts within it share strong similarities with the island-hopping campaign of WWII. The next section uses the critical issues from the WWII case study and discusses similarities, differences, and implications.

World War II Analysis and Implications on Adaptive Basing

Chapters 3 and 4 explored the logistical and maintenance aspects of the SWPA. They showed that the tyranny of distance and the requirement to move assets, aircraft, and troops to new locations and immediately launch operations were significant hurdles. These hurdles still exist today and solving these issues is critical to success in Adaptive Basing. The hurdles in maintenance and logistics intensify as aircraft move from one operating location to another or launch and recover at different bases. Although there are similarities between WWII and today's Adaptive Basing, there are immense differences as well. An exploration of these similarities and differences offers insight regarding how today's Airmen might utilize lessons of the past in order to plan for the challenges of the future.

Logistical Implications for Adaptive Basing

Chapter 3 asserted that in the mobilization for war, access to supplies was a critical limiting factor. The distance between the United States and the Pacific theater worsened the problem. In WWII, the United States dealt with the supply access issue by prepositioning assets and partnering with nations in the Pacific for resources and manufacturing. The following section discusses each of the highlighted logistical areas under the Adaptive Basing context.

[8] Brown Jr., Spacy, and Glover III, 22.

Prepositioned assets. In WWII, Pearl Harbor and the Philippines were the main US bases in the Pacific. The United States prepositioned assets at both locations. The Japanese crippled Pearl Harbor on 7 December 1941 and launched a campaign to take the Philippines just 10 hours later. The Japanese understood that the United States would use both bases to launch attacks, so they sought to paralyze them. Had the United States spread out the logistical resources across more locations, the Japanese attacks may not have been as effective. However, if the United States had not prepositioned fighter aircraft, anti-aircraft munitions, and supplies forward, the mobilization effort would have suffered significantly more. Additionally, the United States received goods and manufacturing through the Reverse Lend-Lease. This agreement cut the distance that goods had to travel which equated to a quicker resupply timeline. These solutions to an immediate need for supplies are still valid today.

Today, the United States has bases throughout the region. If a conflict occurred today in the Pacific, the United States has a head start compared to the logistical buildup required during WWII. The US Indo-Pacific Command (USINDOPACOM) has approximately 375,000 military and civilian personnel assigned to the area of responsibility (AOR).[9] The command also oversees five carrier strike groups, 2,460 aircraft, and 200 ships.[10] Despite this seemingly clear advantage for the United States, at least relative to its position in WWII, one must acknowledge the stark difference in context. In WWII, Japan could not project power over thousands of miles using ballistic missiles, as contemporary China can. Figure 3 depicts China's missile arsenal along with ranges. The fact that China's conventional ballistic missiles can reach Guam, Japan, Korea, the Philippines, and many other locations with prepositioned assets

[9] "About United States Indo-Pacific Command," accessed April 11, 2019, https://www.pacom.mil/About-USINDOPACOM/.
[10] "About United States Indo-Pacific Command."

means the United States cannot rely on access to assets at these locations.

Figure 3: China's Ballistic Missiles
Source: Missile Defense Project, "Missiles of China," Missile Threat, Center for Strategic and International Studies, published June 14, 2018, last modified 15 June 18.

Prepositioned assets are still relevant today but will look different due to new partnerships, technologies, and operational concepts. In WWII, the United States had four regional bases, but today the United States has numerous partners in the region. Partnerships with nations in the Pacific provide additional bases for operations and supplies, and increase the number of targets for the adversary. The United States may not have a standing Lend-Lease equivalent with partner nations, but military exercises, investment in manufacturing skills and equipment,

and studying of resources within the southwestern Pacific region all offer avenues for rapid mobilization.

Logistical infrastructure. Admiral Nimitz and General MacArthur dealt with a lack of existing logistical infrastructure. Only a limited number of deep-water ports existed, friendly airfields were difficult to find, and island-hopping created supply storage issues. Each factor made sustainment more challenging, but lessons can be extracted from each and applied to today.

The lack of deep-water ports made the logistical movements difficult, but leadership in WWII attacked the problem by creating a prioritized offloading system. One of the most critical factors is working with nations early to gain support for port access. The Chinese also recognize the importance of ports and have accumulated a "portfolio of at least 40 ports in North and South America, Africa, the Middle East, Eastern Europe, Central Asia, South and Southeast Asia, Australia and the Pacific."[11] Additionally, China built artificial atolls and islands in the Spratly Islands to house military assets and to serve as a harbor for large ships. China plans to make one of these artificial islands, Fiery Cross, the largest logistics hub in the region. With such an emphasis on port access by a competitor, the United States must identify ways to not only ensure its own access but find ways to complicate or restrict port access for an adversary.

Today, the issue of port access remains, but new options offer potential solutions. More countries in the Pacific region have ports now. New ports offer the United States more places to dock and unload supplies. Additionally, ships of different sizes are available to maneuver through different depths of water. New amphibious vehicles allow the United States to move supplies to a new location more efficiently. Lastly,

[11] John Lee, "China's Trojan Ports," *The American Interest* (blog), November 29, 2018, https://www.the-american-interest.com/2018/11/29/chinas-trojan-ports/.

air refueling, more flexible cargo airplanes, and helicopters afford the United States ways to move supplies to and from island locations that lack a deep-water port. Current airlift assets can carry a substantially higher cargo load over longer distances compared to aircraft in WWII. For example, the C-5 Super Galaxy carries up to 48 times the cargo weight of the WWII C-47 Skytrain and travels over three times farther. [12] The C-130 and C-17 provide the capability for landings on semi-prepared surfaces, like dirt. Landing on semi-prepared surfaces requires personnel and equipment to assess, open, and operate an airfield, as the engineer amphibious brigades did in WWII.

The US forces in the Pacific moved from one island to another by way of amphibious landings, constructing airfields, and ushering in aircraft. The Army ensured the success of those operations partly through the creation of the engineer amphibious brigades. The EAB created the logistical infrastructure necessary to set up quickly and sustain a base for operations. All EABs were deactivated shortly after WWII. A similar requirement remains valid today.

Interoperability between the services was disjointed at best in WWII. Today, after failed operations (e.g., Eagle Claw) and the Goldwater-Nichols Act, the United States functions through multi-service planning and execution. By no means are US joint operations always smooth or successful, but steps were taken to enhance interoperability. The DoD, for instance, created the Air Land Sea Application Center to further the joint cohesion in combat. The center, along with senior leaders from each service, acknowledged the importance of airfield opening and created the "Multi-service Tactics, Techniques, and Procedures for Airfield Opening." This document lays out each service's

[12] Lockheed Martin, "C-5 Super Galaxy Product Card," accessed April 11, 2019, https://www.lockheedmartin.com/content/dam/lockheed-martin/aero/documents/c5/c5_product_card_m11-1132343a.pdf.

capabilities and offers specific suggestions for future base opening operations.

The Air Force, for its part, created an organic capability for this specific purpose, the contingency response group (CRG). "The CRG mission is to assess; open; and, initially, operate airfields."[13] The skills required to accomplish the CRG mission, along with the Rapid Engineer Deployable Heavy Operational Repair Squadron Engineers (RED HORSE) are analogous to that of the EABs. In the future, the DoD must exercise these airfield opening capabilities in realistic austere environments, and not just with US services, but partner nations too.

Currently, only one CRG exists in the USINDOPACOM AOR.[14] This one unit is well-positioned geographically but lacks the manpower and resources to handle a rapid mobilization for a war with China, but the capability is well-suited to answer the logistical infrastructure issue. Therefore, the United States needs additional CR and RED HORSE units, across the globe to enable a faster mobilization and more efficient sustainment efforts.[15] These units also have a unique capability to assist in humanitarian aid and disaster relief missions, which builds trust with potential partners and allows the units to hone their skills. The following section takes the maintenance analysis and overlays the context of Adaptive Basing to understand where aircraft maintenance was and where it could go.

---

[13] Air Land Sea Application Center, "Multi-Service Tactics, Techniques, and Procedures for Airfield Opening," October 2018, 89–90.
[14] "36th Contingency Response Group," accessed May 15, 2019, https://www.andersen.af.mil/36crg/.
[15] RED HORSE "provides a highly mobile civil engineering response force to support contingency and special operations worldwide. Units are self-sufficient with rapid response capabilities conducting independent operations in remote, high-threat environments. They provide heavy repair capability and construction support to recover critical facilities, utility systems including airfield runways." from "RED HORSE Mission," Air National Guard, accessed May 15, 2019, https://goang.com/discover-ang/missions/ground-support/red-horse-mission.html.

Aircraft Maintenance Implications on Adaptive Basing

As with the logistics analysis, this study argued that certain factors were critical to how the Pacific campaign in WWII ultimately played out. Not all the highlighted areas were ones of immediate success. In fact, most challenges arose from a lack of foresight or resources, and the same is true in the analysis of aircraft maintenance in the WWII Pacific campaign. This section examines those factors highlighted in Chapter 4, the need for rapid growth in maintainers and access to parts, and discusses them in today's context.

Maintenance training. In WWII, three factors led to a significant maintainer shortage: a rapid growth of aircraft inventories, the added complexity in aircraft systems, and the rapid deployment of depot-level mechanics. The necessary growth also meant that the United States needed to train military and civilian mechanics to fill the voids quickly. The increasing complexity of the aircraft in WWII drove the maintenance career field towards specialization. This specialization produced maintainers more knowledgeable on a specific aircraft system, but removed some flexibility for maintainers to work on other planes. That said, the combat situations often drove the maintainers to learn new platforms with on the job training. Each of these factors remains important today.

The complexity of aircraft has only increased in the past several decades, and maintainers operate in aircraft-specific system specialties, e.g., F-16 avionics or C-130J hydraulics. WWII showed that creating a specialized maintainer decreased flexibility in the field so today's force could structure training to increase flexibility. As the military trains maintainers, a focus on basic aircraft maintenance offers flexibility to learn a base knowledge that is applicable across specializations and platforms. Cross-training maintainers on multiple platforms comes with a cost in manpower and time to season an inexperienced mechanic. The

temporary maintainer shortfall created by cross-training could be addressed through hiring contractor-mechanics or additional accessions in the maintenance field.

In the Adaptive Basing construct, aircraft maintainers are a linchpin of success. The past two decades of steady-state operations in the Middle East decreased the need for flexible aircraft maintenance operations. Why take the additional risk of teaching a maintainer to work on a new aircraft at a main operating base (MOB) with established aircraft-specific maintainers? However, if flexibility is necessary to Adaptive Basing, where aircraft are dropping in at FARPs and moving throughout the theater, landing at bare-bones bases, then one can imagine the possibilities if the Air Force trained some maintainers as more of a "generalist maintainer." The generalist maintainer could perform basic through-flight inspections and requirements, like launch and recovery, oil, fuel, and tires, on multiple aircraft, reducing the necessary footprint at each location.

How does the DoD bridge the gap between the current construct of a force with specialized mechanics who can operate on multiple platforms? Interactive tools in training and operations are one answer. Technology offers enormous advantages in training. In 2018, Air Force MSgt Thomas Crider used augmented reality (AR) in a maintenance training prototype to offer overlaid checklists, technical orders, and videos on actual aircraft parts.[16] Smaller laptops, powerful tablets, and cell phones offer portable training devices for maintainers too. Utilizing these or other technologies offers an avenue to use the basic knowledge from basic training and expand the maintainer's capabilities to other less familiar specializations.

---

[16] "Air Force Announces Spark Tank Finalists," U.S. Air Force, accessed April 11, 2019, https://www.af.mil/News/Article-Display/Article/1424614/air-force-announces-spark-tank-finalists/.

Continuation training. World War II brought thousands of newly built aircraft and dozens of different models of aircraft. New models rolled off assembly lines straight to the front lines. Maintainers in the field had to deal with aircraft from other services, other units, and newly-minted planes that they did not study in previous schools. Maintenance training units (MTUs) dealt with this challenge by providing the most up-to-date information from the factories to the front lines via a traveling team of expert mechanics that taught new systems.

If Adaptive Basing is to offer agility and flexibility, different types of aircraft will have to land in austere locations, potentially unannounced. Maintainers must be ready to, at a minimum, diagnose general minor malfunctions and service aircraft for launch. The training section above discussed the benefits of augmented reality for maintainers, but the idea of MTUs offer flexibility in today's context as well. The traveling instructors could teach refresher training, updated procedures, and training on new aircraft. This mobile training construct could expand to more than just maintainers and offer an effective way for troops in other lines of work to gain new knowledge while reacquainting oneself with previous data. In today's environment, MTUs do not need to have a team of experts traveling to combat zones but may be in the form of short videos uploaded to a video sharing platform for deployed maintainers to view. The MTUs could use AR and have deployed maintainers enter a virtual classroom that allows each user to see the aircraft parts in 3D as the instructors discuss new procedures. A virtual training environment provides rapid updates to the field and AR allows each maintainer to see 3D models without having to take an aircraft away from a flying mission to visualize the parts. Continuation training from MTUs offered WWII maintainers with a tool to teach new aircraft and specialties to mechanics in the field, and a virtual training environment can accomplish the same today.

Access to parts. Training offers areas for future flexibility in a conflict, but if parts and access to depot level maintenance are not available, then the training is for naught. In WWII, maintainers waited on parts, which reduced the number of aircraft for operations. The Allies partially answered the lack of access and storage by creating floating maintenance depots and supply ships. These ship-based repair facilities offered a significantly closer place for higher order maintenance compared to flying an aircraft back to the US. However, in today's environment, it does not seem plausible that an Air Force aircraft would land on a ship to receive depot level maintenance. Furthermore, the air refueling, vertical lift, and commercial transportation capabilities decrease transit time to depot facilities and offer additional transportation methods not available in WWII.

In the current context, there are other ways to increase access to maintenance supplies. First, additive manufacturing or three-dimensional (3D) printing is a manufacturing process that heats a material (aluminum, steel, plastics, etc.) to a melting point and then feeds the material through an extruder nozzle on to a build plate. Each additional layer of filament builds the object in 3D. Printing in 3D reduces wasted materials and allows for new design structures that subtractive manufacturing did not permit.

General Electric (GE) is 3D printing fuel nozzles for their aviation engines. Additionally, the Catalyst, GE's new turboprop engine, will have one-third of its components additively manufactured. The company reduced the number of parts in the Catalyst engine from 855 to 12, reducing weight and increasing fuel efficiency.[17] Furthermore, 3D printing offers repair capability directly onto the broken part. Like welding, a computer maps the part and the defect and directs the printer

[17] "GE's Catalyst | GE Aviation," accessed May 5, 2019, https://www.geaviation.com/bga/engines/ge-catalyst.

to rebuild the necessary components. The ability to print parts on demand cuts the need for inventory storage, allows for faster part delivery, and a 3D printer is more maneuverable than an entire engineering floor at a manufacturing plant.

Summary

Adaptive Basing is a construct with package deployment options built in to remain agile and complicate the enemy's strategy. The advantages of such a construct help mitigate the tyranny of distance and requirement to move quickly but complications will likely arise, and they will likely resemble those found during the WWII island-hopping campaign. Just as in WWII, prepositioning assets, port access, and logistical infrastructure remain vital to the success of operations. Alliances and partnerships are crucial to positioning supplies. Port access remains significant to the US. Regional partnerships are vital to helping ensure port access in the future. Airfield opening teams from WWII were Army soldiers, but today a joint effort under the ALSA Center provides synergistic capabilities.

The section on aircraft maintenance in Adaptive Basing discussed the importance of training and access to parts. Virtual classrooms offer benefits for both initial and continuation training. Access to parts in WWII proved difficult due to a lack of storage, a long supply chain, and low flexibility. Today, access to parts is still critical to success in Adaptive Basing, and 3D printing offers a possible answer to the limitations in WWII. Agility is only an option if it is ingrained in a culture.

Chapter 6

Conclusion

General MacArthur and his troops pulled off a fantastic feat in the southwest Pacific campaign. They moved hundreds of thousands of men and countless tons of supplies across the Pacific Ocean to fuel a war ignited by a surprise attack on US soil. The War Department and the president prioritized the European theater over the Pacific theater, meaning that General MacArthur and Admiral Nimitz needed to be resourceful and flexible. The two most challenging factors that plagued most of the war plans were the vast distance between the United States and the theater of war and the quick movement necessary in order for the United States to remain in an advantageous position relative to the enemy.

Chapter 2 detailed the tribulations experienced and victories won during the SWPA and highlighted the issues of distance and speed mentioned above. The logistical analysis chapter (Chapter 3) offered insights into the logistical efforts through the lenses of pre-war mobilization and sustainment. It identified two areas that were critical to mobilization and sustainment efforts in the war against Japan. First, access to supplies proved difficult throughout the United States build-up for war, though prepositioned assets and partnerships for local resources and manufacturing (Reverse Lend-Lease) eased the burden. Second, the lack of existing logistical infrastructure, to include ports, storage, and airfields, complicated logistics in the Pacific. The military partially mitigated the difficulty through prioritized port unloading, engineer amphibious brigades, and floating supply barges.

The maintenance analysis chapter used the same construct of mobilization and sustainment to examine aircraft maintenance. It offered three critical focus areas in the campaign. First, with steep

growth in numbers, complexity, and models of aircraft, the United States needed to grow the maintainer force by quickly training new recruits. The AAF cut training length and created new courses to build a base knowledge with the understanding that on-the-job-training would fill in gaps in knowledge. In the field, maintainers received new aircraft or major modifications to existing aircraft. To continually educate the deployed maintenance force, the AAF created traveling instructor teams to refresh existing and teach new information. Next, access to maintenance supplies and parts proved difficult when the United States moved from one island to another. The problem continued, but solutions like predictive part consumption tables and floating supply and maintenance depot ships partly mitigated the burden. The identified focus areas shed light on the areas that proved critical to the ultimate success of the Pacific campaign.

In today's context, Adaptive Basing is a construct that the DoD could employ to provide options and operational flexibility to combatant commanders. The options include moving from base to base, like the island-hopping campaign of WWII. Other ideas include forward locations for aircraft to stop in fuel, rearm, and even change aircrew members and launch for additional missions. Strong similarities exist between Adaptive Basing and island-hopping. For example, in WWII the Japanese already controlled islands that the United States wanted, meaning the US forces had to perform amphibious landings, control beachheads, and assess and construct bases. Today, Adaptive Basing could include these amphibious operations and airfield opening capabilities.

Since future operations might resemble or reflect past ones, it is essential to take the highlighted focus areas and look for current solutions. Chapter 5 used the lessons from WWII discussed the applicability of similar solutions today. For example, the EABs were vital to airfield construction and operation in WWII. Today, the CRG and RED

HORSE are analogous capabilities that might answer a lack of logistical infrastructure in a potential conflict. Another example is the difficulty in WWII to access parts for aircraft maintenance. This issue remains, but additive manufacturing or 3D printing offers high potential to decrease required storage and inventory and increase flexibility. The DoD must continue to exercise and operate with partner nations to ensure future interoperability and pave the way for rapid mobilization, effective sustainment with the highest flexibility.

Glossary

Depot-level Maintenance – (Third Echelon Maintenance) Provides the capability to maintain materiel coded for organizational, intermediate and depot levels of maintenance. Includes maintenance requiring the overhaul, upgrading, or rebuilding of parts, assemblies, or subassemblies, and the testing and reclamation of equipment as necessary.

Intermediate-level Maintenance – (Second Echelon Maintenance) Provides the capability to maintain materiel coded for organizational and intermediate level repair in back shops and or centralized repair facilities.

Organizational-level Maintenance - (First Echelon Maintenance) Provides the capability to launch and recover sorties, as well as to maintain and repair materiel coded for organizational level repair.

Bibliography

"36th Contingency Response Group." Accessed May 15, 2019. https://www.andersen.af.mil/36crg/.

"506th Fighter Group Captain Abner Aust: 506th Fighter Group, 457 Fighter Squadron, 458 Fighter Squadron, 462 Fighter Squadron Lawrence Smith 472601." Accessed February 23, 2019. http://www.506thfightergroup.org/mustangsofiwo.asp.

AAF Historical Office. "The Maintenance of Army Aircraft in the United States, 1939-1945." Headquarters Army Air Forces, August 1946. Air Force Historical Research Agency.

"About United States Indo-Pacific Command." Accessed April 11, 2019. https://www.pacom.mil/About-USINDOPACOM/.

"Air Force Announces Spark Tank Finalists." U.S. Air Force. Accessed April 11, 2019. https://www.af.mil/News/Article-Display/Article/1424614/air-force-announces-spark-tank-finalists/.

Air Land Sea Application Center. "Multi-Service Tactics, Techniques, and Procedures for Airfield Opening," October 2018.

Arnold, Henry. *Report of the Commanding General of the Army Air Forces to the Secretary of War*. U.S. Government Printing Office, 1944.

———. *Second Report of the Commanding General of the Army Air Forces to the Secretary of War: February 27, 1945*. U.S. Government Printing Office, 1945.

Arnold, Henry Harley. *Third Report of the Commanding General of the Army Air Forces to the Secretary of War*. Superintendent of Documents, 1945.

Bergerud, Eric M. *Fire in the Sky: The Air War in the South Pacific*. Westview Press, 2000.

Brown Jr., Maj Gen Charles, Brig Gen Bradley Spacy, and Capt Charles Glover III. "Untethered Operations: Rapid Mobility and Forward Basing Are Keys to Airpower's Success in the Antiaccess/Area-Denial Environment." *Air and Space Power Journal* 29, no. 3 (2015): 12.

Coakley, Robert W., and Richard M. Leighton. *Global Logistics and Strategy, 1943-1945*. Center of Military History, United States Army, 1986.

Dammeier, Maj David, Lt Col Meka Toliver, and Capt Logan Smith. "Overcoming a Power Projection Problem." *CE Magazine*, 2016. https://www.afcec.af.mil/News/CE-Online/Article-Display/Article/1004470/overcoming-a-power-projection-problem/.

Engineers of the Southwest Pacific 1941-1945. U.S. Government Printing Office, 1947.

Engineers of the Southwest Pacific: 1941-1945 ... By the Office of the Chief Engineer, General Headquarters, Army Forces, Pacific .... Amphibian Engineer Operations. U.S. Government Printing Office, 1959.

Engineers of the Southwest Pacific 1941-1945...: Airfield and Base Development.... U.S. Government Printing Office, 1951.

"GE's Catalyst | GE Aviation." Accessed May 5, 2019. https://www.geaviation.com/bga/engines/ge-catalyst.

Griffith, Thomas E. Jr. *MacArthur's Airman : General George C. Kenney and the War in the Southwest Pacific*. 1 edition. Lawrence, Kan: University Press of Kansas, 1998.

Kenney, George Churchill. *General Kenney Reports: A Personal History of the Pacific War*. USAF Warrior Studies. Washington, D.C: Office of Air Force History, U.S. Air Force, 1987.

Lane, Frederic Chapin. *Ships for Victory: A History of Shipbuilding Under the U.S. Maritime Commission in World War II*. JHU Press, 2001.

Lee, John. "China's Trojan Ports." *The American Interest* (blog), November 29, 2018. https://www.the-american-interest.com/2018/11/29/chinas-trojan-ports/.

Lockheed Martin. "C-5 Super Galaxy Product Card." Accessed April 11, 2019. https://www.lockheedmartin.com/content/dam/lockheed-martin/aero/documents/c5/c5_product_card_m11-1132343a.pdf.

Maddox, Robert J. *The United States And World War II*. Routledge, 2018. https://doi.org/10.4324/9780429495786.

Masterson, James Raymond. *U.S. Army Transportation in the Southwest Pacific Area, 1941-1947*. Transportation Unit, Historical Division, U.S. Army, 1949.

Mattis, Jim. "Summary of the 2018 National Defense Strategy," n.d., 14.

Nalty, Bernard C., John F. Shiner, and George M. Watson. *With Courage: The U.S. Army Air Forces in World War II*. Edited by Alfred M. Beck. Washington, DC: Air Force History & Museums Program, 1994.

O'Brien, Phillips Payson. *How the War Was Won*. Cambridge University Press, 2015.

Office of Air Force History. *Men and Planes*. Vol. 6. The Army Air Forces in World War II. DIANE Publishing, n.d.

Papararone, Christopher. "Army Logistician." *Army Logistician* PB 700-95-1 (1995).

"RED HORSE Mission." Air National Guard. Accessed May 15, 2019. https://goang.com/discover-ang/missions/ground-support/red-horse-mission.html.

Roblin, Sebastien. "Why China's DF-26 Missile Is a 'Guam' Killer and a Nuclear Killer." Text. The National Interest, November 9, 2018. https://nationalinterest.org/blog/buzz/why-chinas-df-26-missile-guam-killer-and-nuclear-killer-35847.

Schreiber, O. “Tenth Anniversary of Lend-Lease: How America Gave Aid to Her Allies.” *The Australian Quarterly* 23, no. 3 (1951): 64–67. https://doi.org/10.2307/20633372.

Spector, Ronald H. *Eagle Against the Sun: The American War with Japan*. Free Press, 1985.

US Army Center for Military History. *Logistics in World War II: Final Report of the Army Service Forces : A Report to the Under Secretary of War and the Chief of Staff by the Director of the Service, Supply, and Procurement Division, War Department General Staff*. Center of Military History, United States Army, 1947.