THE BEAMING SUN:

THE EFFECTIVENESS OF IMPERIAL JAPANESE RADAR

AGAINST UNITED STATES AIRCRAFT

DURING THE BATTLE FOR SAIPAN

By

Daniel J. Schaefer

May 2024

Director of Thesis: Dr. Jennifer McKinnon

Major Department: Program in Maritime Studies, Department of History

ABSTRACT

This thesis endeavors to examine WWII-era Japanese radar emplacements and decipher the technology used during the battle for Saipan in 1944 in order to understand United States (US) aircraft losses. These Japanese search and fire-control radar emplacements allowed the detection and destruction of dozens of US aircraft through anti-aircraft fire on an unprecedented level. The thesis provides the first narrative of the US's underestimation of the effectiveness of Japanese radar capabilities and how it relates to the location of submerged aircraft.

This thesis primarily utilizes archival research, archaeological survey, geographic information system (GIS) analysis, and predictive modeling to locate Japanese radar emplacements and downed US aircraft. The archival research includes obtaining Japanese and US radar technology documentation, US Navy after-action reports, and US and Japanese maps and intelligence reports of Saipan's defensive fortifications. An archaeological survey was conducted in Saipan at "Radar Hill," Naftan Peninsula, Mañagaha Island, and other potential locations of Japanese radar emplacements. Archeological data from the 2019-2023 East Carolina University/Defense POW/MIA Accounting Agency (DPAA) mission was utilized as a part of this research. The locations of lost US aircraft located in Tanapag Harbor and around Saipan were mapped, and a GIS model was created and analyzed to identify specific aircraft and any correlation they may have to the Japanese radar and anti-aircraft emplacements. Ultimately, this research attempts to predict the potential for aircraft losses in relation to radar location and range, thus contributing to site locations and individual site formation. Japanese radar technology is a severely neglected technological innovation in the historical record of the Pacific War, and Saipan and its archaeological signature provides a case study to examine its effectiveness.

Key Words: radar, Japanese radar, WWII, anti-aircraft, aircraft, predictive modeling, GIS

THE BEAMING SUN:

THE EFFECTIVENESS OF IMPERIAL JAPANESE RADAR

AGAINST UNITED STATES AIRCRAFT

DURING THE BATTLE FOR SAIPAN

A Thesis

Presented to the Faculty of the Department of History

East Carolina University

In Partial Fulfillment of the Requirements of the Degree

Master of the Arts in Maritime Studies

By

Daniel J. Schaefer

May 2024

Director of Thesis: Jennifer McKinnon, Ph.D.

Thesis Committee Members:

Nathan Richards, Ph.D.

David Stewart, Ph.D.

Dedication

For the scouts of the 101st Airborne Division, 1st Battalion 506 Infantry Regiment, HHC, "Blacksheep" Reconnaissance Platoon. Their efforts sparked my interest in radio communications and enabled me to comprehend similar Imperial Japanese radar principles. Most importantly, they forged a brotherhood through sweat and fire. You guys taught me the importance of always being perceptive, giving it your all, and never leaving a comrade behind.

Currahee!

-Blacksheep-6R

ACKNOWLEDGMENTS

This thesis began when I sought to uncover why there were so many US aircraft losses during the battle for Saipan, many of which remain submerged and unlocated around the island, when the mainstream historical narrative describes Japanese aircraft and anti-aircraft weaponry as being infamously antiquated throughout the Second World War. If this indeed was true, I wanted to know why so many US aircraft were lost in a supposed surprise attack during the battle for Saipan in 1944. I soon discovered the Imperial Japanese Navy had advanced radar capabilities during the Second World War and identified emplacement after emplacement on Saipan. So much so, that I uncovered that Saipan was the first time Imperial Japan operationally employed fire-control radar. This thesis is the first to examine the archaeological and historical evidence of the effectiveness of Japanese radar at Saipan and its relation to US aircraft wrecks. It is also one of the very few historical sources to analyze Imperial Japanese radar technology. These discoveries would not have been possible without the great assistance of many individuals.

Notably, these advances in adding to the historical narrative of the Second World War were only possible with the mentorship of my advisor, Dr. Jennifer McKinnon. Throughout this thesis, she provided vital guidance, support, and assistance throughout my edits, research, and fieldwork on Saipan. Also, many thanks to my committee members, Dr. Nathan Richards and Dr. David Stewart, who provided essential feedback and critiques that made this thesis possible.

Additional thanks to Trent Telenko, who had assisted with the technical capabilities of WWII radar, particularly those of the Japanese. His interest in Japanese radar and experience as the Quality Technical Lead in the Defense Contract Management Agency provided essential technical assistance for understanding Japanese radar capabilities.

Finally, I want to give a special thanks to local guide and historian Fred Camacho, with whom I worked throughout this thesis. The present archeological locations of the radar emplacements could not have been determined without Fred’s expert navigational skills and local knowledge. We spent countless hours in the jungle, machete in hand, hacking away to locate the Japanese radar emplacements on the island. His local wartime knowledge of the island is unparalleled, and he is an all-around great guy and friend.

TABLE OF CONTENTS

LIST OF FIGURES

ABBREVIATIONS

AA Anti-Aircraft

AAA Anti-Aircraft Artillery

AAR After Action Report

CIA Central Intelligence Agency

CNMI Commonwealth of the Northern Mariana Islands

DPAA Defense POW/MIA Accounting Agency

FOIA Freedom of Information Act

GIS Geographic Information System

HPO Historic Preservation Office

IFF Identify Friendly or Foe

IJN Imperial Japanese Navy

IJA Imperial Japanese Army

MIA Missing in Action

NARA National Archives and Records Administration

NRL Naval Research Laboratory

PACBAR Pacific Barrier Radar

SBD Scout Bomber Douglas

SCR Set, Complete, Radio

SLC Search Light Control

TBF Torpedo Bomber Grumman

TBM Torpedo Bomber General Motors

USS United States Ship

VHF Very High Frequency

UXO Unexploded Ordnance

VP Patrol Squadron

Chapter 1 Introduction

The archeological analysis of Japanese radar capabilities and their effectiveness is an understudied topic. Historically, the effectiveness of Japanese radar is often ignored due to preconceived notions that the US had an overwhelming and complete industrial and intellectual monopoly over Japan before and during WWII (Macdonald 2021; Hallas 2019; Galati 2015; Peatie 2015). WWII studies and post-war battle narratives of the battle for Saipan have neglected to address and analyze Japanese radar technology development and effectiveness during the war. The small island of Saipan, along with the other Mariana Islands in the western Pacific, acted as the lynchpin of the defensive network that protected the mainland territory of Imperial Japan from US attack and invasion. Japanese radar technology was critical for the island's defense. As such, the battle for Saipan provides an excellent case study for analyzing Japanese radar capabilities. It was the first island the US invasion force encountered with comprehensive radar coverage through multiple search radar and fire-control radar emplacements. From the initial moments of the battle, Japanese search radar detected the US invasion fleet on 11 June 1944 (Stafford 1962:167). Additionally, an abnormally accurate and heavy anti-aircraft (AA) fire was reported in US aviators' after-action reports (AARs) during the battle. Interestingly, a surviving Japanese Mark 4 Model 3 fire-control radar was captured during the battle and was shipped to the Naval Research Laboratory (NRL) in Washington, DC, to develop countermeasures and jamming capabilities, demonstrating the success of its capabilities (Bonham and Lonsdale 1945). Still, the cause of these Japanese radar successes was never explained, even though the Japanese anti-aircraft fire was infamous for its inaccuracies (USS *Lexington* 1944a).

The chapters of this thesis on the effectiveness of Japanese radar during the battle for Saipan are organized, and Chapter 1 provides an introduction and overview of Saipan. This chapter presents the thesis research questions on Japanese radar. Additionally, the chapter provides site introductions of the Japanese radar emplacements with the intended methods, justification for the research, and potential limitations. Chapter 2 provides further background knowledge on the specifics of radar and how it works. Special attention is given in this chapter to the history of the research and development of Imperial Japanese radar and a background on the battle for Saipan. Chapter 3 details the methods utilized in this thesis and details how survey fieldwork was conducted. This chapter further describes the extensive historical and archival research conducted. Lastly, the chapter describes the analytical methodology conducted, primarily through an ArcGIS fields of fire model relating Japanese radar emplacements to downed US aircraft locations. Chapter 4 describes the history and capabilities of Japanese radar and the types of search, fire-control, and airborne radar systems believed to have been used in the Saipan theater of operations. The history and capabilities of the types of US aircraft downed during the battle are also detailed. The history and capabilities of Japanese anti-aircraft weaponry utilized with radar to down these aircraft are also described, as well as the history of US military electromagnetic radar countermeasures and capabilities of Japanese radar. Chapter 5 analyzes the archaeological data collected from the survey site locations. Notably, it analyzes the data from the created ArcGIS fields of fire model representing Japanese AA's highest concentration fields of fire that partnered with radar and the concentration's relationship to downed US aircraft locations. Lastly, Chapter 6 acts as the conclusion of the thesis, where the historical and archeological research results are discussed, as well as the potential for future research.

This thesis proposes that the accuracy of Japanese radar enabled the downing of dozens of US aircraft, having precisely and quickly locked in on their location. It also proposes that the ranges of the radar emplacements and the related fields of fire of Japanese anti-aircraft emplacements can be predictive in locating additional downed US aircraft from the battle. The thesis research contributes to understanding the overall usage of Japanese radar during the Second World War and specifically during the battle for Saipan. The intellectual depreciation of the US towards the Japanese and their technological capabilities in radar ultimately cost the lives of dozens of airmen at Saipan and thousands of airmen throughout the war. Japanese radar detected a US invasion fleet through search radars and often gave over an hour of warning to the defender's aircraft and anti-aircraft emplacements. These search radars would lock in on US aircraft, knowing their numbers, azimuth, and altitude well before reaching an island from their aircraft carriers (Nakagawa 1997:44). Via radar, the Japanese could direct dozens of their anti-aircraft emplacements through radio communication and fire-control directors to focus all fire accurately and heavily towards one specific aircraft or aircraft formation. Saipan was the first time these comprehensive layers of radar coverage were used in Japanese defenses. Thus, it acts as the perfect case study on its effectiveness. Through their industrial capabilities and widely published technological innovations, the superiority complex of the US victors obscured most of the propagated innovation of the Japanese during the Second World War. An example of this obscurity can be seen in Japanese radar technology being concealed by US military leadership to cover early significant inefficiencies in their own radar technology.

1.1. Brief Overview of Saipan

Saipan is an island in the western Pacific Ocean of the Mariana Islands chain (Figure 1). It is approximately 14 mi. long and 5 mi. wide, with approximately 45 sq. mi. in landmass (Figure 2). Human settlement goes back 4,000 years, eventually becoming permanent with the native Chamorro population. The island was first encountered and recorded by Europeans in 1521 by Spanish explorer Ferdinand Magellan. The Spanish officially settled on the island in 1668, adding the island to their imperial dominion. They occupied Saipan until 1898 when the island was sold to Germany following Spain's defeat during the Spanish-American War. Following World War One and Germany's defeat, the occupied land was ceded to Japan in 1919. The island's infrastructure expanded exponentially through Japanese occupation to support the economically fruitful sugar cane industry. Throughout the 1930s, Imperial Japan also began building up the island's defenses (Hoffman 1950:2-3). This construction effort led to Saipan becoming the lynchpin of Imperial Japan's defenses during World War Two. Saipan's defenses faced and eventually fell to a US amphibious invasion and battle lasting from 11 June 1944 to 9 July 1944. Following the island's capture, the US occupied Saipan, and it became a trust territory following the war. In 1978, the Northern Mariana Islands became a Commonwealth of the US, and Saipan became the capital of the Commonwealth of the Northern Mariana Islands along with the remainder of the island chain sans Guam.

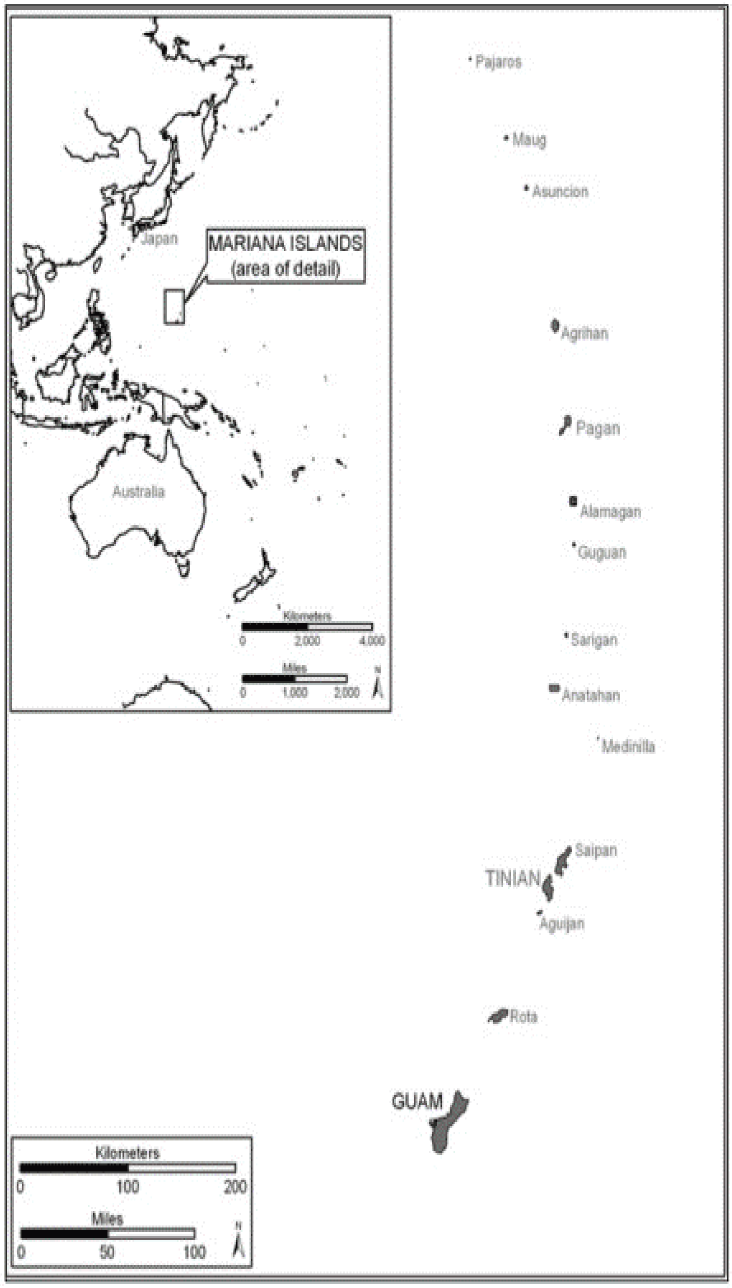


Figure 1. Location of Saipan and the Mariana Islands (Hoffman 1950:3).

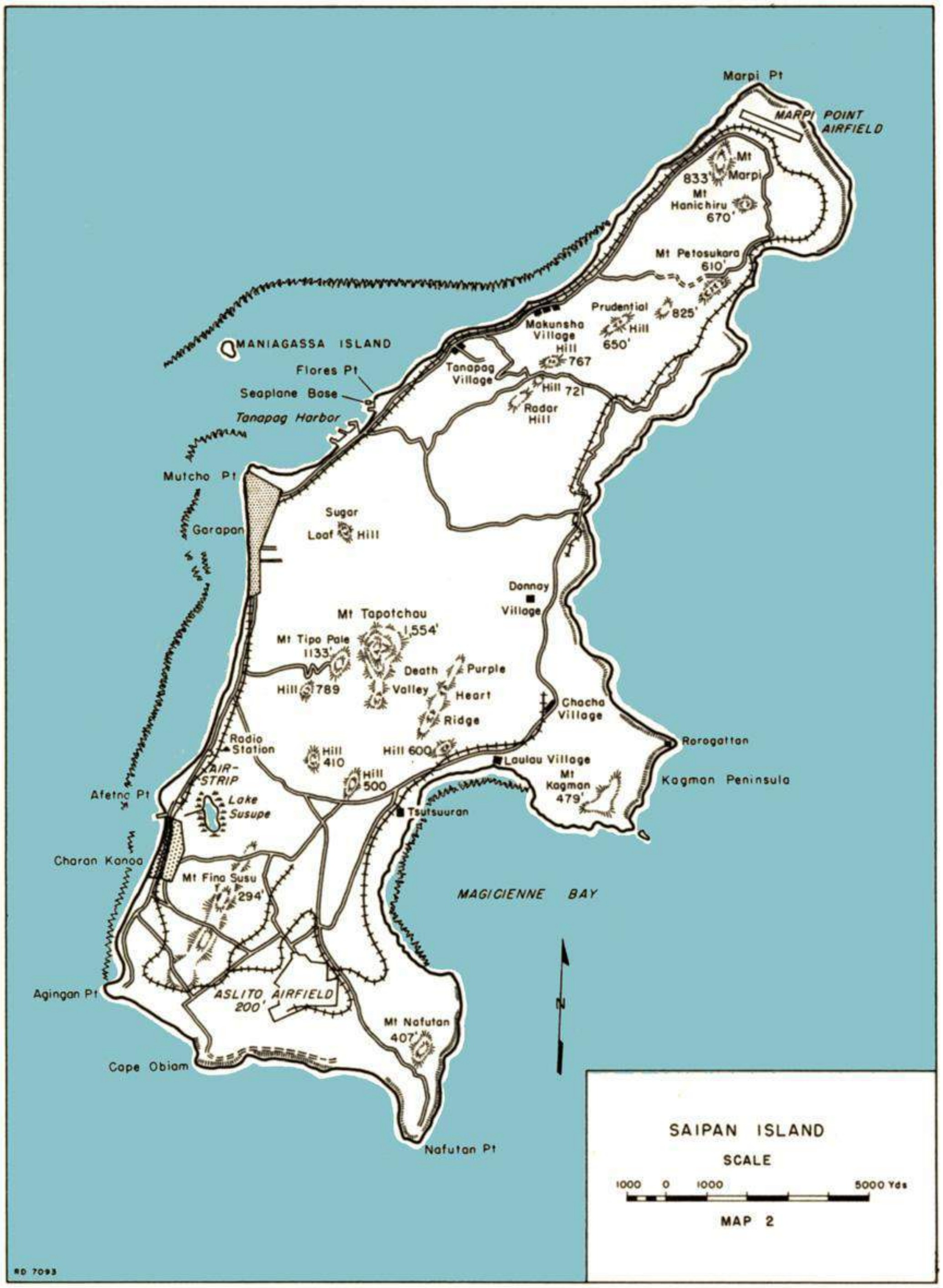


Figure 2. Overview 1944 map of Saipan (Hoffman 1950:5).

1.3. Research Questions

The primary question explored in this research is "What was the effectiveness of Japanese radar technology and emplacements used at Saipan, and how did that impact the record of losses and locations of US aircraft?" The geographical terrain of the Japanese radar emplacements was analyzed to determine the tactical significance of the location. Additionally, considerations of elevation and line of sight were confirmed through archival sources and archaeological survey, as these are essential for precise radar detection and facilitation of radio wave communication between the radar emplacements and their command of anti-aircraft installations.

The thesis plots all known US aircraft downed by Japanese anti-aircraft fire through Japanese radar emplacements using a geographic information systems (GIS) platform. This was conducted to determine if and how the Japanese radar emplacements on Saipan detected and destroyed US aircraft. Archaeological surveys were conducted on the Japanese radar emplacements, related Imperial Japanese Navy (IJN) structures, and specific US aircraft wrecks, particularly those downed in Tanapag Harbor. An attempt was made to determine the cause of the downed aircraft through anti-aircraft fire to confirm the US Naval after-action reports of unusually "heavy and accurate" fire from Japanese anti-aircraft emplacements on Saipan (USS *Lexington* 1944a).

To accomplish these goals, the following questions were considered during research:

1. Where are the Japanese search and fire-control radar emplacements located on Saipan, and why did the Japanese choose the locations?

2. How does the location of the Japanese radar emplacements relate to the location and site formation of downed US aircraft around Saipan?
3. Why did US forces underestimate Japanese radar technology and were unaware of their fire-control radar use?
4. Why did US aircraft attack Tanapag Harbor, given its heavy Japanese anti-aircraft emplacements rather than naval bombardment?
5. How did the Japanese detect the US invasion fleet off Saipan? Why were the Japanese aircraft not scrambled at Aslito Airfield?
6. Can a predictive model for Japanese anti-aircraft fields of fire determine where additional downed US aircraft are located?

1.4. Site Introduction

Saipan was the site of Operation Forager from 11 June to 9 July 1944, where the US broke off Imperial Japan's final defensive perimeter that protected its mainland islands. US aircraft victims of the Japanese radar emplacements located on Saipan have been identified since the initial fieldwork of the side scan sonar and magnetometer survey of Tanapag Harbor in 2008 (Burns 2008). East Carolina University conducted fieldwork focusing specifically on target testing in the harbor in 2018, where a Grumman F6F-Hellcat was identified, and a Grumman TBM-Avenger was reassessed in 2018. The propeller of another Grumman F6F-Hellcat was also believed to have been located (McKinnon 2019). The Japanese radar emplacement locations on Saipan were initially determined through recovered archival data and local oral histories, where further archeological survey could be conducted. This thesis examines four potential Japanese radar emplacements on the island of Saipan. Those radar emplacements were believed to have been located on "Radar Hill," Naftan Peninsula, Dandan Village, Mount

Petosukara, and nearby Tinian if physically feasible. The Japanese radar emplacement locations had been forgotten since 1945 and had never been deliberately recorded before this thesis.

The primary and heavily vegetated archaeological site goes by many names that still harken back to its past as a communications epicenter, such as “Radar Hill,” and today it is still known as Wireless Ridge. The Chamorro name for the site is *Talofofo*, or "between bubbling springs" (Fred Camacho March 2022 pers comm.). Local informants and historians were unaware of the significance of Japanese radar emplacements on Saipan. Local historian and expert guide Fred Camacho was also previously unaware of the several Japanese buildings located there, which are the most complete he had ever seen, particularly of structures located in the center of the island.

On Radar Hill, these Japanese structures that likely were used as the IJN command apparatus for the defense and operation/maintenance of the area's many radar and communication apparatuses were examined. Captured Japanese radar documents confirm the existence of a Japanese radar emplacement having been located there. The peak of “Radar Hill,” with a clear line of sight of the west and east approaches of the island, was additionally examined as this location would have offered an optimal line of sight of the Mark 1 Model 1 search radar (Naval Research Laboratory 1943).

Offshore of Saipan, Mañagaha Island was believed to be the location of a Japanese radar emplacement where US submarines scouted out Japanese radar in 1944 (Lotz 2018:128). The most notable archaeological remains reported on the island are located on the eastern face, where multiple Japanese anti-aircraft emplacements remain submerged as the island has heavily eroded in the decades following the battle. The site was repeatedly archivally observed as a Japanese radar emplacement site and would have been ideal given Mañagaha Island's guarding nature of the harbor.

Naftan Peninsula is a densely forested jungle peninsula located on the southernmost portion of the island. Captured Japanese radar documents and intelligence gained from aerial reconnaissance confirm the existence of a Japanese search radar emplacement having been located there. The archeological remains along the Naftan Peninsula are substantial, and the area has remained relatively untouched since the battle. The jungle of the Naftan Peninsula is exceptionally dense, and wartime structures are obscured. It was believed that this would be true with the Japanese radar emplacement located there.

Dandan Village is located on the eastern end of Aslito Airfield, where US intelligence recorded a Mark 1 Model 3 search radar emplacement. Through intelligence photographs, the emplacement appeared to have walls constructed of wood and a roof of tin with a camouflaged Mark 1 Model 3 antenna mast. The emplacement was recorded 1,300 yds. north of the eastern end of Aslito Airfield and presently would be located in the built-up area of Dandan Village.

Notice was additionally given to a "dummy" radar emplacement, recorded in battle archival intelligence reports, located in the northern portion of the island on Mount Petosukura near the PACBAR (Pacific Barrier) III Cold War radar emplacement. Although not logistically physically possible for survey during this thesis research, Tinian Japanese radar emplacements were also located on Mount Lasso and off the northern Japanese airfield. Military intelligence reports reported an additional radar emplacement in the south of Tinian. Travel blogger Howard Cole had previously located the radar emplacement on Mount Lasso, but it has never been officially archaeologically surveyed (https://hiketinian.blogspot.com/2008/02/tinians-japanese-radar.html). There is much additional future survey potential for Japanese radar emplacements on the island of Tinian.

1.5. Methodology

The 2008 side scan sonar and magnetometer survey of Tanapag and Garapan Lagoons and the fieldwork since that time, specifically from 2018, have defined some US aircraft locations downed by anti-aircraft fire and enabled through Japanese radar (Burns 2008, McKinnon 2019). Some types of submerged US aircraft were established, and the potential identification of any possible recovered remains of the aviators flying the aircraft is underway through a partnership between ECU and the Defense POW/MIA Accounting Agency (DPAA). Attempts were made from collected data to confirm the cause of the aircraft downing using a GIS framework and show the relationship of the aircraft's destruction to the location of the Japanese radar emplacements and their detection range. Additional attempts were made to establish through GIS that the invasion fleet was detected through Japanese radar on 11 June 1944.

Comparative analyses of US aircraft anti-aircraft fire losses were established to understand the efficiency of Japanese anti-aircraft fire at Saipan. All the downed aircraft were plotted through GIS modeling with their location (or approximate if MIA) and cause of destruction noted. The aircraft downing locations towards the Mark 4 Model 3 fire-control radar are expected to be higher the closer in distance they are to the radar emplacements. The location of Japanese radar sites and their efficiency at Saipan was attempted to be determined primarily through US intelligence reports at various archival sources and through Freedom of Information Act (FOIA) requests.

ArcGIS will be utilized to create predictive modeling for downed US aircraft around Saipan from the fields of fire of Japanese anti-aircraft guns and ranges of radar emplacements. Through the predictive modeling, it is expected where the fields of fire of the anti-aircraft guns overlap are the locations that would be likely sites of downed US aircraft, as Japanese flak was the heaviest in those locations. Remote sensing methodologies can then be used on those more site-specific locations to facilitate the attempt to locate some of the dozens of missing-in-action US aircraft.

Archeological surveys were conducted on the believed Japanese radar emplacement locations at Radar Hill, Mañagaha Island, Naftan Peninsula, and Dandan Village. Additional survey potential exists for the Tinian radar emplacements, as they were within Saipan’s airspace's detection range.

Before further fieldwork was established, comprehensive historical and archival research was conducted. This thesis extensively examined archival wartime maps and documents to locate the radar emplacements and their capabilities. Also examined were maps from Saipan's Historic Preservation Office, which contains a partial record of recorded concrete structures likely from the Japanese occupation and battle.

The examination of technical reports of the captured Japanese radar sets from the Naval Research Laboratory in Washington, DC, were heavily considered. A research focus was also given to the captured translated Japanese radar documents from Kwajalein Atoll in January 1944 (Price 1984:143). Japanese documentation related to their radar capabilities, particularly at Saipan, was analyzed through US Naval Intelligence technical reports. There was also attempted research cooperation with the Japanese Military Radio Museum in Yokohama, Japan, which contains an operational power supply and transmitter unit of the Mark 4 Model 3 fire-control radar like the one likely captured on Radar Hill. The museum also has a Mark 1 Model 3 transmitter and power supply units identical to those likely utilized in Mañagaha and Dandan Village. Technical assistance on the capabilities of Japanese radar was through discussions with retired Quality Technical Lead in the Defense Contract Management Agency, Trent Telenko.

Archaeological evidence at the Japanese radar emplacement sites was photographed and mapped, with models created through ArcGIS. Further land surveys were established, focusing on Radar Hill and Naftan Peninsula, to locate the exact location of the Japanese radar emplacements in 1944. Special consideration was given to attempting to locate electrical component artifacts. There is likely not much of the radar components remaining unless they were severely damaged, as most components were scrapped or disassembled and sent to the Naval Research Laboratory in 1944. Further research needs to be established on what happened to the Mark 4 Model 3 fire-control radar following the war.

1.6. Justification

The examination of Japanese radar capabilities through a historical lens has been analyzed from a minimal perspective. It has been neglected through US wartime biases against the industrial and intellectual capabilities of the Japanese Empire. All observed recently published narratives related to the battle for Saipan continue that bias and neglect that the Japanese defenders utilized radar technology on the island. Meanwhile, the effective use of Japanese radar at Saipan can be uncovered through analysis of US Naval after-action reports that reported "heavy and accurate" anti-aircraft fire when Japanese anti-aircraft fire was known for its inaccurate nature (USS *Lexington* 1944a). Saipan suddenly sustained one of the most significant US battle losses through Japanese anti-aircraft fire at this point in the war. Additionally, how the invasion fleet was compromised has never been explained in any narrative of the battle for

Saipan. This thesis attempts to prove that the Japanese radar detected the invasion fleet on 11 June 1944. This will also assist in the location of additional downed US aircraft using overlapping fields of fire of Japanese anti-aircraft fire. It is suspected that additional aircraft will be located near the highest concentration of AA fire.

1.7. Limitations

Perhaps the most significant limitation of the research was the lack of comprehensive secondary publication on Japanese radar. The only exception is *Japanese Radar and Related Weapons* (1997) by Yasuzo Nakagawa, which is 82 pages long and focuses on the pre-war story of Japanese radar technology. As such, a focus on wartime after-action and US Naval Intelligence reports was undertaken.

The most apparent limitations of this thesis were cost and time. Since the survey is not directly related to the government-funded work of DPAA and MIA (Missing in Action) recovery, various grants were thought to be required for further fieldwork. Costs would include flights, housing, permits, and additional personnel to survey the locations on “Radar Hill,” Mañagaha Island, and Naftan Peninsula. Due to the potential cost and limited time, surveying each Japanese radar emplacement was limited in duration.

The issue of management and ownership plays heavily into this thesis. Through an initial survey of Saipan’s Radar Hill, command structures associated with the maintenance and operation of radar emplacements were believed to have been located there. It is believed these structures are some of the most complete standing Japanese buildings located in the center of the island (Fred Camacho March 2022, pers. comm.). These resources are currently on private property, with the owners previously unaware of their significance. The landowners have asked that the sites' specific coordinates not be brought to public knowledge. Yet, public knowledge of these sites' importance would help further the cultural value for locals, tourists, and historians, helping completely change the standard narrative of the battle for Saipan and the significant role that Japanese radar played in it.

Chapter 2 Background

2.1. How Does Radar Work?

Radar comes from a 1940 US Navy acronym for the technology, which means Radio Detection and Ranging. Radar works through transmitted pulses of radio wave energy sent out to travel along a straight-line path or beam. When the pulse hits an object that radio waves cannot penetrate, the waves are reflected and bounced back to the receiving element of the radar module (Figure 3). Radar operates in a monostatic function where the transmitter and receiver are in one location or in a bistatic function where the transmitter and receiver are in separate locations (Figure 4). A monostatic radar has the benefits of simplified operation, with the transmitter and receiver being in the same location. In contrast, bistatic radar often overcomes geographical blind spots, interference, and jamming. A radar operator can then deduce the object's azimuth, distance, and speed through an oscilloscope (Figure 5). Distinct types of radar modules are enabled for various roles, but through a military lens, they are primarily utilized through three roles. The first role is an early warning aerial search radar to locate enemy aircraft for early detection. The second is a surface search radar, most commonly used to detect enemy forces where the radar transmitter and receiver are oriented to the earth's surface. It is most used in a maritime role as the sea is accessible from most foliage and terrain obstructions, and enemy ships and surfaced submarines can easily be detected. The third role of radar through a military lens would be fire-control, which radar can be enabled to automatically lock in and track enemy aerial targets and automatically relay this information to anti-aircraft gun emplacements to destroy the enemy aircraft.

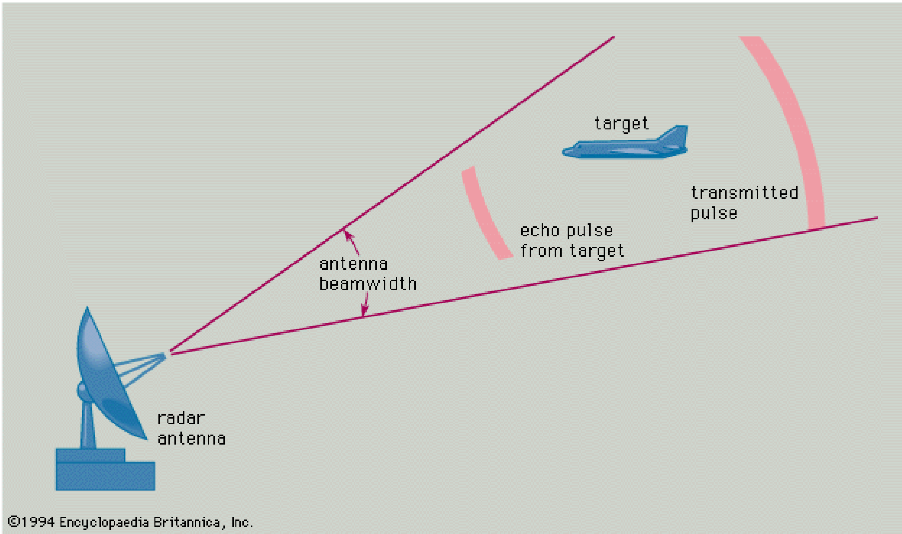


Figure 3. Radar fundamentals (Skolnik 2023).

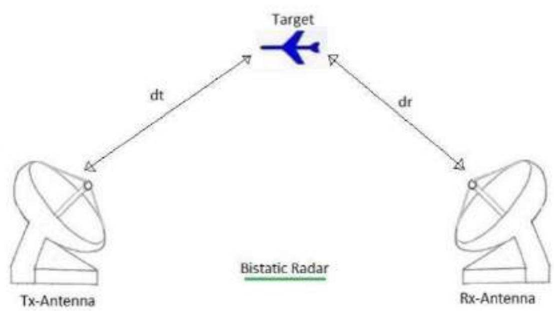


Figure 4. Bistatic radar fundamentals (RF Wireless World 2012).

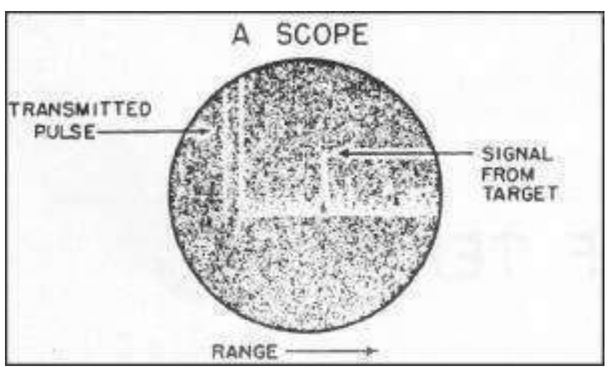


Figure 5. Transmitted and received radar pulse on scope (Sub-Committee of the Joint Committee on New Weapons and Equipment 1943:109).

2.2. HISTORY OF EARLY RADAR

Japanese radar usage during WWII is one of the most neglected technological subjects by historians of the Second World War (Nakagawa 1998). Most of the public and even many historians are unaware that the Japanese even had radar capabilities during the war, while the few that are aware typically view Japanese radar as being primitive and several years behind Allied radar technologies (Peattie and Evans 2015:411-413). The study of radar technology in the Pacific Theater is often an afterthought, if any at all. For the Second World War, historians generally focus on the early radar of Chain Home in 1940 during the Battle of Britain, which saved the island by detecting and warning of wave after wave of incoming German aircraft (Swords 1986:131-35). Meanwhile, the Japanese were developing their advances in radar technology, so much so that in 1939, Japan was considered by some the most advanced in radar technology research and development (Galati 2015:74-76).

Throughout the 1930s, the Japanese Empire fully embraced technological innovation in a laboratory setting. Even in the early 1930s, Japan considered radar a viable technical prospect to further their war machine. The need for early detection of US aircraft and naval forces to defend the ever-growing Japanese colonial empire was what propagated innovation (Nakagawa 1997:6). In the 1930s, the Japanese were far more technically advanced beyond the radar capabilities of the US, Great Britain, and Germany in most theoretical approaches (Galati 2015:76). The Japanese name for radar was *Denpa Tanshingi*, which meant "Radio Wave Probe." They were so advanced in radar that they were the first to develop the cavity magnetron in 1939 (Nakajima 1992:12). The cavity magnetron operated by utilizing microwave technology in radar, allowing extraordinarily accurate and rapid detection rather than through the standard long-wave radio wavelengths that other nations had uniformly used during this time (Nakagawa 1997:15-17).

2.3. Japanese Radar Development During WWII

As the war expanded against the US after the attack on Pearl Harbor on 7 December 1941, most laboratory innovations related to the war effort were initially sidelined. Japan drafted most of its highly trained and specialized technicians into the military, halting their significant technological head start over the Allies (Nakagawa 1997:42-43). Additionally, there was little cooperation between the Imperial Japanese Navy (IJN) and the Imperial Japanese Army (IJA) in competing sectors of radar research and development (Nakagawa 1997:47-48). However, the IJN and IJA both fully understood the essential need for radar. The observed effectiveness of Allied radar modules of the Signal Corps Radio (SCR)-268 fire-control radar and the Signal Corps Radio (SCR)-270 search radar achieved this realization (Nakagawa 1997:34). Both modules were designed by the US in 1940 and captured by the Japanese in 1942 at Corregidor, Philippines. US research and development in land-based fire-control radar would stagnate, mainly through the SCR-268 radar, as it would only be replaced in late 1944 (Henney 1945:103). Meanwhile, its capture reinvigorated Japanese radar development, bringing it out of the labs and into mass production with a more advanced model of their own (Nakagawa 1997:34).

In 1941, the Japanese rapidly brought their technology into total industrial production after discovering how effective radar technology was for the US (Nakagawa 1997:43). The Japanese radar technology found by US forces during their first significant land engagement came as a complete shock. US intelligence had yet to consider that the Japanese were utilizing radar technologies, vastly believing that the Japanese were not capable of practically fielding their own technological innovation through the industrial and intellectual superiority complex of the US at that time (Grunden 2005:272). At the Guadalcanal, Solomon Islands airfield, the US Marines captured a Mark 1 Model 1 IJN land-based detection radar (Naval Research Laboratory 1943). Shocked intelligence analysts shipped the radar module to the Naval Research Laboratory in Washington, DC, for analysis. It was determined to be nearly identical to the SCR-270, as Japan copied it from the radar module captured the previous year from Corregidor.

This surprising discovery prompted US intelligence to examine the full capabilities of the Japanese Mark 1 Model 1 radar potential. They determined that the operational frequencies of the captured SCR-270 and the Japanese Mark 1 Model 1 radar were in an identical range of 104-112 MHz. (Nakagawa 1997:86). US aircraft and submarines installed radar detection and receiver units to monitor the frequency range and locate additional Japanese radar emplacements like the one found at Guadalcanal (Lotz 2018:21). In March 1943, the mission of the first graduating class of the Army Electronic Warfare School was to detect a Japanese Mark 1 Model 1 radar on Kiska on a B-24 Liberator flown over Japanese-occupied terrain in the Aleutian Islands (Price 1984:53-55). The aircraft's analytical systems could determine the radar emplacement's location through its operating frequency range, pulse width, pulse repetition rate, and area coverage (Price 1984:277-79). Through radar detection units located on US aircraft and submarines, the US found dozens of similar Japanese radar emplacements throughout the Pacific region (Lotz 2018:21). The effectiveness of this electronic warfare campaign caused Japanese radar emplacements for a time, particularly on naval vessels, to turn off their emitters to avoid detection (Nakagawa 1997:49-50). In 1943, the only type of Japanese radar identified by US intelligence was the Mark 1 Model 1, but through concealed Japanese research and development, their radar technology was rapidly evolving behind the scenes (Price 1984:137).

These newfound discoveries of masses of Japanese radar led to further reconnaissance efforts to locate and identify Japanese radar emplacements throughout the Pacific. The US submarines *Greenling* and *Whale* of Patrol Area 14 detected three Japanese radar emplacements in Saipan starting on 8 March 1943 (Lotz 2018:198). Initially, a periscope detected the emplacements rather than the use of electronic warfare methodologies. Even if the submarines were utilizing electronic warfare, they would not have been able to detect many of the newly designed Japanese radar emplacements on Saipan, as they were among the most advanced Imperial Japan had developed under different operating frequencies. Through visual surveillance, the submarines confirmed the location of Japanese radar off the western cliffs of Naftan Peninsula, the eastern approach of Mañagaha Island, and notably at the center of the island in the mountains (Lotz 2018:91). It was assumed that all radar modules found on Saipan were identical to Guadalcanal's radar, but they were mistaken (Price 1984:137).

A pivot in signal intelligence was made in January 1944 with the capture of Kwajalein Atoll. Japanese documents captured on the island revealed the existence of multiple modules of Japanese radar. Most significantly, the documents confirmed the existence of the Mark 2 Model 2 Japanese ship-borne radar that operated on precise microwave frequencies (Price 1984:143). These new developments should have been more adequately considered, but again, the US sidelined them for other intelligence considerations that were deemed more important.

2.4. Operation Forager

Task Force 58 was the US Naval Fleet assigned to attack the center of Imperial Japan's Pacific empire (Macdonald 2021:186-89). The fleet comprised an array of 17 aircraft carriers, six battleships, 13 cruisers, 58 destroyers, and 1,100 aircraft (Macdonald 2021:235). This display of firepower gave the invading US forces of Saipan an overwhelming sense of superiority over their Japanese enemy. Morale was high as US aircraft had bested Japanese defenses at Truk Lagoon in February 1944 against the severely inaccurate Japanese anti-aircraft fire, resulting in almost no US aerial casualties (Stewart 1985:107). Task Force 58 had decimated the heavily fortified harbor of Truk, and this success gave the US forces much overconfidence in their attack on Saipan less than four months later.

Meanwhile, Saipan fortified itself into a defensive bastion for the Japanese Empire as the command headquarters for the IJN and the anchor point for “Operation Z” of Japan’s final intended defensive perimeter (Hallas 2019:41). General Yoshitsugu Saitō commanded the IJA and the IJN was led by Admiral Chūichi Nagumo, who had been sidelined to an administrative post after his failure at the Battle of Midway (Hallas 2019:20). Being the location of the IJN headquarters, it would have been afforded all the premier technology of the Japanese Empire, including the available Japanese radar technology and their most capable radar operators.

When the fleet of Task Force 58 arrived off the coast of Saipan on 11 June 1944, Japanese radar on the island had the fleet locked in through their radar systems long before they arrived and were prepared for the US attack (Macdonald 2021:235-237). The US fleet arrived off Saipan’s eastern approach from the Marshall Islands, where the first arriving action of 225 US aircraft was to weaken the Japanese defenses through aerial bombardment (USS *Lexington* 1944a). Naval aviator and historian Edward P. Stafford described the initial attack on 11 June 1944 as, "To avoid enemy radar, the fighter sweep stayed low. Then thirty minutes from the target, planes assigned to high cover began their climb; twenty-five minutes out, intermediate cover started up and twenty minutes out, low cover..." and "despite the precautions, radar had warned the Japanese" (Stafford 1962:167). The Japanese were not able to scramble all their aircraft as they had almost all been parked and degassed to prevent an explosion during a US air raid. Approximately 40 aircraft got in the air and approximately 60 aircraft were destroyed on Aslito Airfield, with nearly all being lost. Their sacrifice though provided Japanese AA emplacements ample opportunity to zero in on US aircraft. After the initial June 11th attack, the radar emplacements would have been on priority one operation with 24/7 detection coverage, confirming that this was not a raid on Saipan like the one on 22 February 1944 and that the invasion surface fleet was approaching the island, which Imperial High Command would confirm to Saitō.

Japanese radar detection of TF 58 was essentially inevitable, as there were Japanese search radar emplacements located on Mañagaha, Naftan, Radar Hill, off Aslito Airfield, and potentially 2-3 search radar emplacements on Tinian within range of Saipan. The radar warning system over Saipan was incredibly layered, and it is unlikely that any US aircraft could surprise the island without their detection. Notably, the Japanese Mark 1 Model 3 radar emplacement had a maximum detection range of 300 km. of the US Mark III IFF (Identify Friendly or Foe) systems (Nakajima 1992:20). It acted as an installed military transponder on most US aircraft and surface naval vessels where radar pulses were transmitted and were read by an interrogator module of the IFF to determine friendly from enemy aircraft. Due to its operating frequency, though, it essentially lit an electromagnetic flare on its location for the radar scopes of the Japanese Mark 1 Model 3 search radar.

The US naval bombardment began two days later, on 13 June 1944, near Naftan Peninsula and Aslito Airfield, but was inaccurate due to the inexperience of the crews in the naval bombardment and fears of getting too close since Saipan was falsely suspected of having been heavily mined (Hallas 2019:78-79). Throughout the battle, multiple waves of aircraft were launched to attack the island, where the aircraft were primarily F6F Hellcat fighters, Torpedo Bomber General Motors (TBM) and Torpedo Bomber Grumman (TBF) Avenger torpedo bombers, and SBD Dauntless dive bombers. Their targets from 11-15 June 1944 before the troop landings were primarily around the area of Tanapag Harbor, where the bulk of the Japanese supply vessels were anchored (USS *Lexington* 1944a). Tanapag additionally functioned as the primary headquarters element of the IJN and IJA on the island (Hallas 2019:68)

Being essential to the Japanese command structure on the island, Tanapag had extensive anti-aircraft emplacements located around it. Multiple emplacements were potentially linked and had wireless radio communication with the Mark 4 Model 3 fire-control radar on the island. The Mark 4 Model 3 fire-control radar AA emplacement was likely located less than two miles from Tanapag, enabling it to observe the approaching US aircraft when they lifted off from their carriers. The Japanese fire-control radar let the defenders know the altitude at which US aircraft were flying, their number, and their azimuth, and they had the aircraft automatically tracked. The fire-control radar then automatically relayed this information to anti-aircraft emplacements on the island through radio and AA directors or fire-control computers to set their guns and fuses to the appropriate setting to focus fire on a single target or formation (Nakagawa 1997:33-34). The US aircraft flew into a trap, unaware of the radar-directed flak awaiting them. Their overconfidence in their attack against Tanapag even caused them to refrain from conducting pre-sortie reconnaissance of the site before their attack or considering a naval bombardment (USS *Lexington* 1944a).

US aircraft arrived over Tanapag and was met with “heavy and accurate” anti-aircraft fire. US Navy historian Samuel Morison describes Japanese AA at Saipan as being "evident that Japanese anti-aircraft fire had vastly improved during the past year" (Morison 1953:178). They were saturated by flak on levels never seen before by the US in the Pacific Theater and were in complete confusion about the accuracy of the fire (USS *Lexington* 1944a). On the first day of the attack on 11 June 1944, there were already 13 US aircraft losses, and dozens of others were severely damaged from Japanese anti-aircraft flak fragmentation. Nearly all downed US aircraft in Tanapag resulted from anti-aircraft fire (USS *Lexington* 1944a). The fire-control radar that assisted in this potentially remained operational until the capture of Radar Hill by the 1st Battalion 24th Marines on 3 July 1944 (Hoffman 1950:203). The transmitting and receiving units of the Mark 4 Model 3 were in near-pristine condition when it was captured, as it posed a tiny target for naval and aircraft bombardment and could easily be obscured. Following the battle, the Mark 4 Model 3 fire-control radar was acquired by US intelligence analysts and was potentially shown being filmed in the 13 July 1944 National Archives footage. US Intelligence was in complete shock by the capabilities of this module when its role as a fire-control radar was determined. The module was disassembled and shipped to the Naval Research Laboratory to develop countermeasures and jamming capabilities. The analysis determined that the radar was even more accurate than land-based fire-control radars that the US was fielding in the Pacific (Bonham and Lonsdale 1945). Testament to the accuracy of the Mark 4 Model 3 fire-control radar are the dozens of submerged aircraft around the coast of Saipan and in Tanapag Harbor. From 11 June 1944 to 9 July 1944, 81 US aircraft were downed over Saipan, with dozens of additional US aircraft being severely damaged and needing substantial mechanical repairs. Sixteen of these US aircraft losses were directly noted as having been lost to Japanese flak, having been assisted by Japanese fire-control radar (Appendix A).

Chapter 3 Methodology

This chapter details the fieldwork methodology conducted to obtain the necessary archeological data for this thesis. The fieldwork was non-disturbance and relied heavily on photographic and pedestrian surveys. The chapter also describes the historical and archival research in the National Archives and through a Freedom of Information Act request. Additionally, this chapter describes the ArcGIS methodologies utilized that correlate the ranges of the Japanese radar emplacements on the island and the concentration of anti-aircraft fire with US aircraft during the battle. The chapter's concluding section details the limitations encountered through the fieldwork and historical/archival research and how data could be hindered.

3.1. Survey Methodology

Fieldwork for this thesis was conducted in March 2022 and May 2023. The fieldwork focused on locating the terrestrial Japanese radar emplacement locations, utilizing non-disturbance methodologies such as pedestrian survey, snorkel survey, and photography. Three locations of Japanese radar emplacements were determined through archival research prior to fieldwork: Radar Hill, Mañagaha Island, and Naftan Peninsula, as well as the confirmation of one dummy Japanese radar emplacement at the present PACBAR III Cold War radar on Saipan. The 2-3 Tinian radar emplacements were additionally considered as they were within range of Saipan. None of these sites had previously been identified as Japanese radar emplacements and had long lost their context and vital importance since the war's end.

3.1.1. Site Survey

Site formation processes were identified for each of the radar emplacement locations. This was primarily to understand the present terrain and foliage characteristics and how similar they were to when the battle occurred in 1944. This would help to understand how a radar emplacement location was chosen. This understanding of the terrain of each Japanese radar emplacement location was primarily gained through various maps through the years since the battle to see progressive changes to a location's terrain and foliage. Multiple archival maps were used as a reference to represent the conditions during the battle and were compared to present Google Earth imagery of the site. Overlays of multiple maps were additionally created on ArcGIS and Google Earth to more clearly represent the changes to terrain and foliage over time. This was optimal for representing a clear line of sight of a location, which radar requires.

Additionally utilized were various weather and local Saipan news reports that could help understand typical weathering or recent erosion qualities that may have affected the geographic appearance of the location. Often, human development considerations affected the status of the appearance of a Japanese radar archeological site. The natural weather erosion, sometimes more turbulent in the form of a hurricane, and nearly constant humidity eroded the aged metal and concrete structures. Thus, there needed to be an understanding at each location that the land's appearance could change dramatically in just 80 years.

Secondarily, this information was obtained through the local knowledge of Fred Camacho and his local informants and observation. For example, on Radar Hill, the potential impact of wildfires was investigated as it has been subjected to wildfires. For example, in 2015, much of the unexploded ordnance in the region was cooked off and exploded through an out-of-control wildfire. In 2023, Radar Hill was again subjected to wildfires, clearing the terrain and giving it a similar charred effect to how it had looked during the battle. The wildfires were optimal for this thesis as they quickly permitted a clear line of sight to be established for the submerged US aircraft in Tanapag Harbor and exposed the previously hidden IJN structures in the dense jungle.

After extensive background research of the site and what to expect at each, precedence was applied to known Japanese radar emplacement locations believed to have the most substantial archeological evidence and the slightest changes in terrain to represent a clear line of sight. Much notice was given to Radar Hill, not only through its name but also its proximity to all presently identified US downed aircraft in Tanapag Harbor, likely making it the emplacement location for the Mark 4 Model 3 fire-control radar. Thus, a pedestrian survey of the location was conducted in 2022 and 2023 with guide Fred Camacho. Photographs of the structures and artifacts were taken, with attention to electrical components, anti-aircraft casings, and Imperial Japanese Navy symbolism. The suspected radar employment field was comprehensively photographed to represent a clear line of sight, and 360-degree coverage was easily accomplished, as well as a clear line of sight to all of the submerged downed US aircraft sites in Tanapag Harbor. An *Icarus* drone was used in the radar employment field, where it was launched and flew vertically for 50 ft. and then at an azimuth to Tanapag Harbor to represent further the clear view the location would have had to US aircraft attacking the harbor.

An attempt was then made to locate the Japanese radar emplacement on the Naftan Peninsula again with Fred Camacho, as he had been on Naftan multiple times and knew the area well. As limited archival and historical research had been conducted on the location at that time and given the density of the jungle during that time of year, the radar emplacement could not be located. Once the thesis author had felt there was a solid foundation for a comprehensive survey in 2023, a brief reconnaissance of Mañagaha was conducted with the author and an East Carolina University crew of a potential radar emplacement located there. Abnormalities in the terrain near the western shore were shown particular attention to. Due to the significant urban development on the land, little remains from the battle could be confidently established.

In 2023, a more thorough comprehensive survey of the building and structures was planned for Radar Hill, but due to last-minute concerns of the private property owners, the focus for the survey was then placed on the Naftan Peninsula radar emplacement. After a year and much archival work had been conducted on the location, the site was pinpointed on GPS coordinates so that Fred Camacho and the thesis author could more easily locate it. Additionally, photographs of the site were located online by a blogger who had been there 15 years prior, and Fred said he recognized the site from the pictures. Even with all the data, due to the density of the jungle, it took approximately two hours to locate the radar emplacement. Upon locating the site, GPS coordinates were taken of critical features of the structure to be easily represented on Google Earth and ArcGIS.

After conducting a comprehensive survey of the Naftan Peninsula radar emplacement, additional survey work was permitted on additional suspected radar emplacement locations. As the pedestrian survey on Mañagaha Island yielded limited results, a snorkel survey was then conducted, focusing on the eastern and western approaches of the island where two East Carolina University teams examined the locations. The western survey was conducted because it had a clear line of sight to the ocean, as a US submarine was reported to have detected a Japanese radar emplacement on the island from the ocean. A snorkel survey was additionally conducted on the eastern face of the island, where multiple known battle-era artifacts remained in a submerged state. These structures and artifacts had multiple scaled photographs taken of them, focusing on features or electronics that might be related to a radar. Upon the completion of the fieldwork period, Radar Hill, the Naftan Peninsula, and Mañagaha Island were effectively surveyed in multiple aspects.

3.2. Archival and Historical Research

Archival and historical research was conducted before fieldwork was conducted. Archival sources needed to be used extensively as there has been limited modern authorship on Japanese radar. Research was focused on the following topics:

● Radar fundamentals and era capabilities

● Research and development of Japanese radar

● IJN radar research and development

● The battle for Saipan Japanese defensive organization

● The battle for Saipan US aerial offensive organization

● Mark 4 Model 3 fire-control radar

● Japanese anti-aircraft weaponry and fire-control

● Mark 1 Model 1 search radar

● Mark 1 Model 2 search radar

● Mark 1 Model 3 search radar

3.2.1. Historical Research

The historical research focused on a broader understanding of WWII in the Pacific, Saipan’s role, and the radar theory of the era and its early development. This was accomplished through secondary text sources, interviews with radar technical experts, interviews with local Saipan cultural and historical subject matter experts, and review of the files of the Historic Preservation Office of the Commonwealth of the Northern Mariana Islands (CNMI).

Historical research provided a better understanding of Japanese radar research and development from the 1930s to the war’s end. Using the sole historical text devoted to Japanese radar, *Japanese Radar and Related Weapons of World War II* (1998) by Yasuzo Nakagawa, a complete understanding of the research and development of Japanese radar was able to be established.

Due to the need for more technical expertise on the radar technology of WWII and its capabilities, subject matter experts were identified. Trent Telenko, who worked for 22 years as a quality control specialist for the Department of Defense's Defense Contract Management Agency, was the primary expert available to help understand radar technology further. He retired as a quality technical lead specializing in assuring the technical capabilities of Department of Defense contracts, including radar technologies, with a personal research interest in Section 22, the covert Allied Japanese radar hunting unit. Through the assistance of Mr. Telenko, confirmation of the advanced technical abilities of Japanese radar was further established.

Personal expertise was additionally used through a cultural and historical lens of Saipan via local guide Fred Camacho. Fred is a local Chamorro and has been hiking and exploring the island's WWII history for over the last thirty years. Through his assistance, local oral narratives could be established on the studied radar emplacement locations and local names of the region, such as through the multiple etymological origins of Radar Hill, often relating directly to its "wireless" past.

A partnership was additionally established with CNMI's Historic Preservation Office (HPO). This was to utilize any potential archival data uncovered from the battle and previous survey work of the radar emplacement on the Naftan Peninsula. The Naftan Peninsula survey was conducted in 1996 to develop a Japanese resort that intended to cover most of the peninsula, thus the Naftan Peninsula Japanese radar emplacement was surveyed. The survey did not note the site's significance or that it was utilized for Japanese radar. The earlier survey work documents were uncovered in HPO's archival room. Unfortunately, the archival data from the battle at HPO is minimal. HPO has been provided from the research of this thesis with a data cache of dozens of uncovered era archival battle documents.

3.2.2. Archival Research

Due to the lack of previous historical research conducted on Japanese radar during WWII, comprehensive archival research was needed. This archival data was predominately collected through digital collections. The primary sources are the digitized archival collection of the Ike Skelton Combined Arms Research Library in Fort Leavenworth, Kansas, and the National Diet Library in Tokyo, Japan. Additionally used was the digital collection of the Australian War Memorial in Campbell, Australia, and the Air Force Historical Research Agency and Air Force History Index in Montgomery, Alabama, for specialized data focusing on the capabilities of Japanese radar. The US National Archives and Records Administration (NARA) was utilized as well, particularly working with them to locate, declassify, and obtain documents relating to countermeasures research and development on the Mark 4 Model 3 fire-control radar at the Naval Research Laboratory in Washington, DC that was captured on Saipan through the FOIA (Appendix B).

The Ike Skelton Combined Arms Research Library contains the most comprehensively digitized World War II operational document collection. The collection is an essential resource as post-WWII, the Command and General Staff College at Fort Leavenworth was provided with these operational reports, including unit-based intelligence, logistics, and after-action reports (AARs) to provide further material to educate higher-ranking officers of captains and above as they are trained to command battalion sized elements where understanding these operational considerations are the most vital ingredients for success. The library contains a comprehensive digitized collection of captured and translated Japanese documents. Many of these documents relate directly to the radar of the Japanese as well as their technical capabilities. Notably, the archives contain a comprehensive collection of intelligence reports from the battle for Saipan, which contain various maps and aerial photos used to construct the location of Japanese defensive fortifications throughout the island.

Japan's National Diet Library Digital Collections archives were utilized as they have comprehensively digitized World War II documents related to the Pacific War, especially documents concerning US Intelligence efforts against Japan. The archives proved especially useful with their comprehensive collection of US after-action reports from the bombing squadrons on the carriers. The digitized archives also contain records of the US Strategic Bombing Survey, including pre-invasion intelligence reports that proved extremely useful in this thesis.

The Australian War Memorial's digital archives collection effectively obtained documentation determining the technical capabilities of individual Japanese radar emplacements. Comprehensive archival data on Japanese radar was obtained through the National Archives of Australia record search partnered with the Australian War Memorial. This was through the collected documentation at the Australian War Memorial of Section 22, a joint Australian and American Japanese radar search and destroy unit stationed in the Southwest Pacific Area. The unit focused its efforts on the detection and destruction of the Japanese Mark 4 Model 3 fire-control radar that was first located on Saipan to develop countermeasures. The Australian War Memorial has documentation detailing how various Japanese radars work, operating frequencies, ranges, and their deadly technical efficiency. Multiple photographs and sketches from Section 22 of the Japanese radar are provided, as well as maps that show the detected Japanese radar and the suspected locations, focusing on the Philippines and mainland Japan.

The Air Force Historical Research Agency, located at Maxwell Air Force Base in Montgomery, Alabama, provides one of the most compressive microfilm archives dedicated primarily to the US Army Air Corps and the US Air Force. The collection is far more easily accessible than through NARA, as specific microfilm collections can be digitally requested and delivered with a rapid response. The desired microfilm can be located online through the Air Force History Index. Particularly important in the microfilm collection are translated Japanese documents relating to their radar usage as well as US intelligence summaries on the effectiveness of Japanese radar against US aircraft, such as the bombing missions over mainland Japan and the countermeasures that were developed.

The US National Archives and Records Administration was last utilized as an archival source for Japanese radar. Unfortunately, these digitized collections are minimal aside from unit "war diaries" that provided detailed unit accounts of unusually heavy Japanese anti-aircraft fire over Saipan. The undigitized documentation in NARA relating to Japanese radar is quite limited compared to the previous archival sources. However, NARA does have a comprehensive digitization of WWII footage. Post-battle footage showing the captured Japanese radar emplacements on Saipan that proved to be very useful in confirming location and status of the radar on Radar Hill and the Naftan Peninsula.

The 81 US aircraft losses over Saipan from 11 June 1944 to 9 July 1944 were compiled through the Aviation Archaeological Investigation & Research organization's online database. The date of 11 June 1944 was chosen as the starting loss date from the start of the US aerial bombardment of the island to the end of the most organized Japanese resistance on 9 July 1944. The aircraft were determined through the *US Navy Overseas Loss List 1941-1945* database, and the losses over Saipan were compiled in a table (Appendix A). The loss circumstances were further confirmed though primarily Fold3's digital military record collection.

All collected archival data relating to the battle for Saipan was compiled into a digital data cache, including countless rare maps, images, and intelligence reports. This data was shared with CNMI's Historic Preservation Office and the National Parks Service located on Saipan to facilitate future displays and research on the battle.

3.3. Analytical Methodology

Through the archival data uncovered, the Japanese radar emplacements were plotted on ArcGIS. Particular attention was given to era archival intelligence maps and current mapping imagery of Saipan. Through ArcGIS, these two maps were able to be georectified. The radar emplacements were plotted on ArcGIS using a "fields of fire" model developed previously by Aleck Tan. Through this model, the radar emplacements are represented in the fields of fire or principal sky watch areas of Japanese anti-aircraft gun emplacement units on the island are represented in areas of overlapping fire as well as the radar emplacements' ranges and distances from known and suspected downed US aircraft locations.

3.3.1. Japanese Radar Emplacements' Detection Range GIS Model

Japanese radar coverage was represented as a layer in the fields of fire ArcGIS model with 360-degree coverage and the radar modules' specific detection ranges enabled. The overlapping radar detection ranges were then represented through the model. The circular ranges of each radar emplacement were represented with varying colors depending on the radar module utilized. The color green represented the ranges of the Mark 1 Model 1 search radar maximum detection range, blue for the Mark 1 Model 3 search radar maximum range, purple for the US

IFF detection maximum range of the Mark 1 Model 3 search radar, gray for the Mark 1 Model 2 search radar, and red for the maximum range of the Mark 4 Model 3 fire-control radar.

3.3.2. Japanese Anti-Aircraft Emplacements Fields of Fire Model

The principal sky watch areas or fields of fire for the Japanese anti-aircraft defenses of the island were georectified through ArcGIS. The area that can be reached through Japanese AA unit weaponry acted as the unit's fields of fire. From a captured Japanese map after the battle, the azimuth of each anti-aircraft unit was plotted throughout the island. This document was then georectified on ArcGIS where the ranges of each AA unit was represented with a triangular light-yellow shaded color field of fire of their respective principal sky watch area. The fields of fire of the Japanese AA units on Saipan were re-established on the created overlay on ArcGIS as triangular basic polygons. The transparency of the triangular fields of fire, represented in yellow color, was then adjusted to 20% for high values and 80% for low values to show the overlap in the fields of fire. The overlap of the fields of fire was more heavily represented through darker shades of yellow, which would likely represent the heaviest anti-aircraft fire from Japanese defenses on the island and the most likely downing locations of US aircraft. The overlapping results through ArcGIS can potentially predict where future magnetometer and survey work can be conducted to search for additional MIA US aircraft shot down by Japanese anti-aircraft during the battle.

3.4. Limitations

The methodologies utilized in this thesis faced various and often entirely unforeseen limitations. The most significant limitation would be the ability to access fieldwork locations through various barriers of often privatized land. This was not a concern for the Naftan Peninsula radar emplacement and Mañagaha Island, as the suspected radar emplacement locations were on public land. Meanwhile, the private landowners variably contested the Radar Hill site. The field where the radar was employed on Radar Hill is public, but the two-story IJN command post compound and separate one-story building are located on a private landowner's property. For the 2022 fieldwork season, the private landowners granted permission to conduct a reconnaissance pedestrian survey and were invited to conduct a more comprehensive one. With this consideration in mind, local guide and contact, Fred Camacho, and the thesis author remained in contact and coordinated an additional survey in the months preceding the May 2023 fieldwork season. Without further explanation and despite repeated attempts, access to survey the Radar Hill structures was denied. Attempts were also made to locate the radar emplacement 1,300 yds. off the east end of Aslito airfield in Dandan Village. Due to the location's residential nature and urban development, only select private landowners in the area could be contacted to give permission to locate potential archeological remains of the Japanese structure on their property.

The ability to properly photograph and survey was also limited through sites on private land and the heavy vegetation of the remote fieldwork sites in the jungle. Dense vegetation would often block the camera's field of view, especially at the Naftan Peninsula radar emplacement. Attempts were made to create a 3-D model of the Naftan Peninsula radar tower through Rhino modeling software using multi-perspective and angular 360-degree photos. The vegetation was so dense that a distanced perspective of the radar tower could not be adequately achieved, and only approximately 50 percent of the 3-D model of the radar tower could be rendered. An effort was made to remedy this limitation by using a drone planned to be launched from the radar tower to provide an aerial and clearer perspective, filming it with 360-degree coverage to fully render a model of the tower. Unfortunately, the radar emplacement was just on the boundary limits of Isley Airport, where the Federal Aviation Administration had exclusive permissions for the airspace, and the drone was not permitted to launch.

The environmental survey was limited to the need for comprehensive annual island mapping. Before the early 2000s, the island's satellite imagery was relatively poor, and yearly aerial photography was unavailable for multiple years. The survey focused on the erosion qualities of Mañagaha Island that occurred sometime in the early 1980s. Due to the lack of data available, it could not be confidently determined what precise year the suspected radar emplacement location and Type 96 AA guns became submerged on the eastern face of the island.

The historical research was limited as there has been virtually no historical authorship on Japanese radar, particularly through secondary sources. Much of this lack of authorship on Japanese radar is through the continued and repeated Pacific War myth of Japanese technical inferiority regarding their abilities in radar. Many Pacific War narratives are entirely ignorant and often do not even mention the usage of Japanese radar during the war.

Archival research was only slightly limited, as nearly all the required documentation was found to be digitized through the archives of the Ike Skelton Library at Fort Leavenworth, Kansas. There were some accessibility issues in accessing archival data on Japanese radar that had not been digitized through some sources. Accessibility was particularly an issue with The National Archives and Records Administration, where virtually none of their archival data on Japanese radar was digitized, and approximately half of the desired archival documents at the Australian War Memorial archives were not digitized.

The fields of fire model for the Japanese radar and anti-aircraft emplacements on Saipan is limited in the variable factors of the ranges. Each radar module has a maximum range to represent its detection of the Task Force 58 invasion fleet, but various environmental conditions could increase or decrease the radar's detection range, and thus, it is an approximation for the range plotting overlap on ArcGIS. Modeling for the most concentrated field of fire of Japanese anti-aircraft was limited as Japanese AA units were plotted rather than the accuracy of each individual AA emplacement. Japanese flak's impact on US aircraft is variable under multiple uncalculated environmental factors, such as the accuracy of each AA emplacement and how far a US aircraft would fly after being fatally hit.

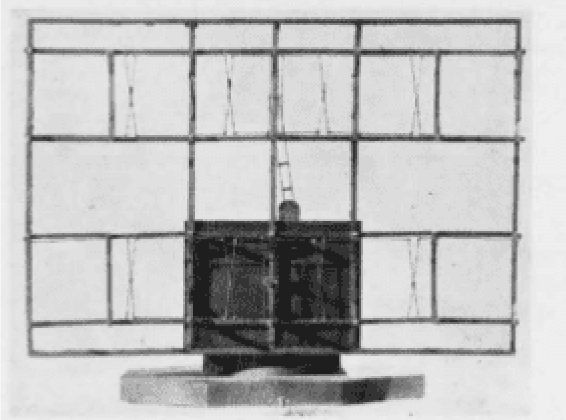
CHAPTER 4 HISTORY

4.1. JAPANESE RADAR

During the battle for Saipan, Imperial Japan employed multiple radar models to defend the island. The following radar models were utilized during the battle, enabling a layered radar detection system through search radar, radar-directed anti-aircraft fire, and an airborne-based search radar. The Japanese did not call their systems radar but rather “radio detectors” for warning radar emplacements and “radio locators” for fire-control radar emplacements (Wilkinson 1946:1). The IJN radar naming system was often varied and confusing and a specific type or model usually referred to the systems. “Mark 1” referred to land-based search radar, “Mark 2” referred to ship-borne radar, “Mark 3” referred to ship-borne fire-control radar, “Mark 4” referred to anti-aircraft fire-control, “Mark 5” referred to airborne search radar, and “Mark 6” referred to ground-controlled interception airborne radar. “Type 1” referred to fixed radar, “Type 2” referred to mobile radar, and “Type 3” referred to portable radar (Wilkinson 1944c:2-3).

4.1.1. JAPANESE MARK 1 MODEL 1 AERIAL SEARCH RADAR

The Japanese Mark 1 Model 1 radar, also named the Type 11 radar and nicknamed the “Guadalcanal Type” radar was developed by the IJN in 1942 (Figure 6). Japanese radar began its development in April 1941 after Imperial Japan realized the essential value for early search radar from the Battle of Britain. Its mass employment was due to the US Doolittle Raid which occurred on 18 April 1942, where US aircraft surprise attacked the heart of Japan in Tokyo through aircraft that had approached undetected (Nakagawa 1998:42-43). Thus, the development of the Mark 1 Model 1 radar was rushed, and it was employed from June 1943 at various and often distant island locations to enable rapid detection of the movement of US aircraft and surface naval vessels (Figure 6). The radar earned its name as the “Guadalcanal Type” as it was the first Japanese radar captured by the US during the battle for Guadalcanal and became the most produced Japanese early warning radar module. Before its capture on Guadalcanal, US military intelligence was unaware that the Japanese had operationally developed the radar past laboratory theoretical experimentations.



GUADALCANAL, SOLOMONS
ABOVE. front view of scale model showing details of the antenna.

Figure 6. Guadalcanal Mark 1 Model 1 search radar (Division of Naval Intelligence 1945:5).

The radar operated on 96.5 to 103 MHz. on the very high frequency (VHF) frequency range, allowing it to have an extensive detection range (Naval Research Laboratory 1943). The early warning detection enabled the Japanese to locate aircraft up to a range of 250 km. for an aircraft group formation and 130 km. for a single aircraft at 40 kilowatts of power (Nakagawa 1997:87). It was a bistatic radar where the transmitter and receiver elements were located separately. The radar consisted of a 26 ft. x 18 ft. rectangular screen of five horizontal half-wave dipole antennas and was backed by a chicken wire mesh-like material (Division of Naval Intelligence 1945:5). Behind the radar screen was a 10 ft. x 10 ft. control shack that would enable the radar to have 360-degree coverage with an operator (Division of Naval Intelligence 1945:6). Located nearby would be a generator for the substantial power required to transmit radar beams and often a fire-control radar that would allow specific aerial targets located by the early warning radar to be targeted with accurate radar-directed anti-aircraft fire.

A modified version of this radar was later developed as the Mark 1 Model 1 Modification 1 or “Attu” radar. The “Guadalcanal” type radar was employed on Radar Hill and the Naftan Peninsula, and the “Attu” type was employed on Mount Lasso on Tinian. The “Attu” type radar had the same range and looked nearly identical to the “Guadalcanal” type except for a different antenna dimension of 28 ft. x 14 ft. (Division of Naval Intelligence 1945:10). A total of approximately 80 Mark 1 Model 1 search radars were produced by Japan throughout the war, with hundreds of additional variants that evolved from it to defend the Japanese mainland later in the war (Wilkinson 1946c).

4.1.3. Japanese Mark 1 Model 2 Aerial Search Radar

The Japanese Mark 1 Model 2, “Mobile Mattress,” or Type 12 radar, was a mobile search variant utilized by Imperial Japan from April 1944 (Figure 7). The radar operated at a frequency of 200 MHz. and had a detection range of 100 km. for a formation of aircraft and 50 km. for a single aircraft (Nakagawa 1997:88). The radar module consisted of a 14 ft. by 7 ft. radar screen mounted on a Type 94 army trailer (Division of Naval Intelligence 1945:14). The radar was employed similarly to the Mark 1 Model 3 radar and the screen and dipole array were similar to those of the “Guadalcanal Type.” The Japanese employed the Mark 1 Model 2 “Mobile Mattress” radar on the northern airfield of Tinian. A total of approximately 300 Mark 1 Model 2 search radars were produced by Japan throughout the war (Wilkinson 1946c).

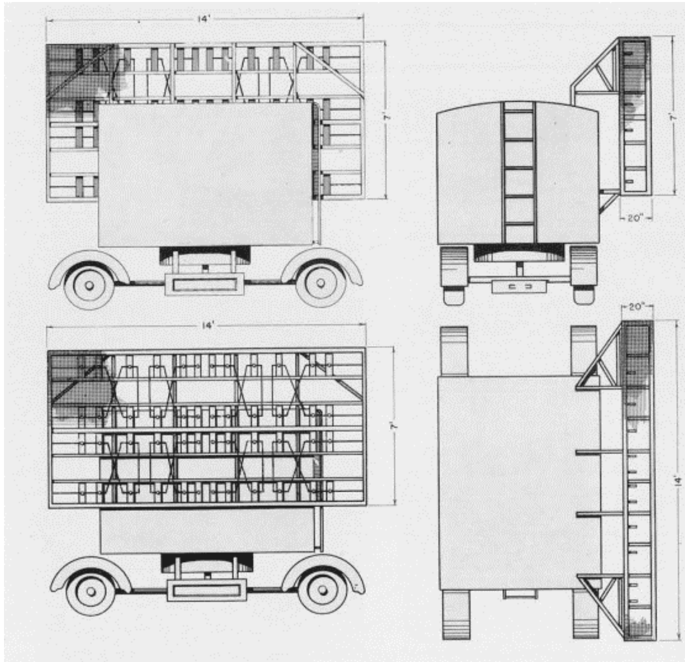


Figure 7. Japanese Mark 1 Model 2 aerial search radar (Division of Naval Intelligence 1945:14).

4.1.2. Japanese Mark 1 Model 3 Aerial and Surface-Search Radar

The Japanese Mark 1 Model 3 or Type 13 early warning radar was a mobile module employed throughout Imperial Japan starting in August 1943 (Figure 8). Its mobile nature beneficially enabled Japanese detection of US aircraft and surface vessels throughout most island-hopping campaigns. The radar was mobile and could easily be adjusted from a surface search radar horizontal polarization to detect naval vessels to vertical polarization to detect US aircraft. So multi-functional was this radar that the IJN adopted variants for their naval and submarine vessels and utilized it on land into their defensive networks. The versatility and effectiveness of this radar proved it to be favored by IJN radar operators. The radar mast was approximately 18 ft. in length with ten 7 ft. dipole antennas mounted (Division of Naval Intelligence 1945:16). The module operated at a frequency of 150 MHz. The radar also worked as a rudimentary IFF for Japanese aircraft equipped with the Mark 6 Model 4 Type 3 radar, as it also operated on 150 MHz. Thus, the echo ping received from the Mark 1 Model 3 radar would be significantly stronger and discernable from regular aircraft contact. The range of the Mark 1 Model 3 radar for a formation of aircraft was 100 km. and 50 km. for a single aircraft.

Notably though, the detection of the US Mark III IFF transponder was enabled as it operated on the same frequencies as the Mark 1 Model 3 radar (Cahill 2017:11). The US Mark III IFF operated on a frequency range from 157-187 MHz., which it cycled through every 2.5 seconds (Mullis 1993:52). Meanwhile the Japanese Mark 1 Model 3 operated at 150 MHz. with both having an additional frequency variance of approximately ± 5 MHz. A frequency range often bleeds into another range through radio harmonics, meaning the US Mark III IFF would transmit signals to the Japanese Mark 1 Model 3 radar at 152-155 MHz. Due to this major flaw of the Mark III IFF, the Japanese radar was able to detect at a range of 300 km. for US aircraft, as almost all were equipped with IFF (Nakajima 1992:12). The IFF was automatically triggered by Japanese radar, which sent radar pulses of its location from the US aircraft to the Japanese radar emplacement as they operated on identical frequencies. This essentially lit an electromagnetic flare on the range and direction of US aircraft, which Japanese radar operators could easily see on their scope at an extended range of 300 km. while its usual detection range for a formation of aircraft was 100 km. They could then alert the local airfields to scramble and anti-aircraft emplacements to be readied. The frequency range of the Mark III IFF was never remedied until 1952 after having continual US aircraft compromised and destroyed in the Korean War when it was finally replaced by the Mark X IFF (Hallion 2011:76). The Mark X operated on single frequencies and the enemy could not trigger the IFF without the proper code.

On Saipan a Mark 1 Model 3 search radar was employed 1,300 yds. off the eastern end of Aslito Airfield in Dandan Village and likely monitored Aslito Airfield traffic. The Mark 1 Model

3 radar was also potentially employed on Mañagaha Island to particularly watch US surface vessels and submarines potentially attempting to enter Tanapag Harbor, survey Saipan defenses, and destroy Japanese surface vessels. A total of approximately 1,500 Mark 1 Model 3 search radars were produced by Japan throughout the war (Wilkinson 1946c:12).

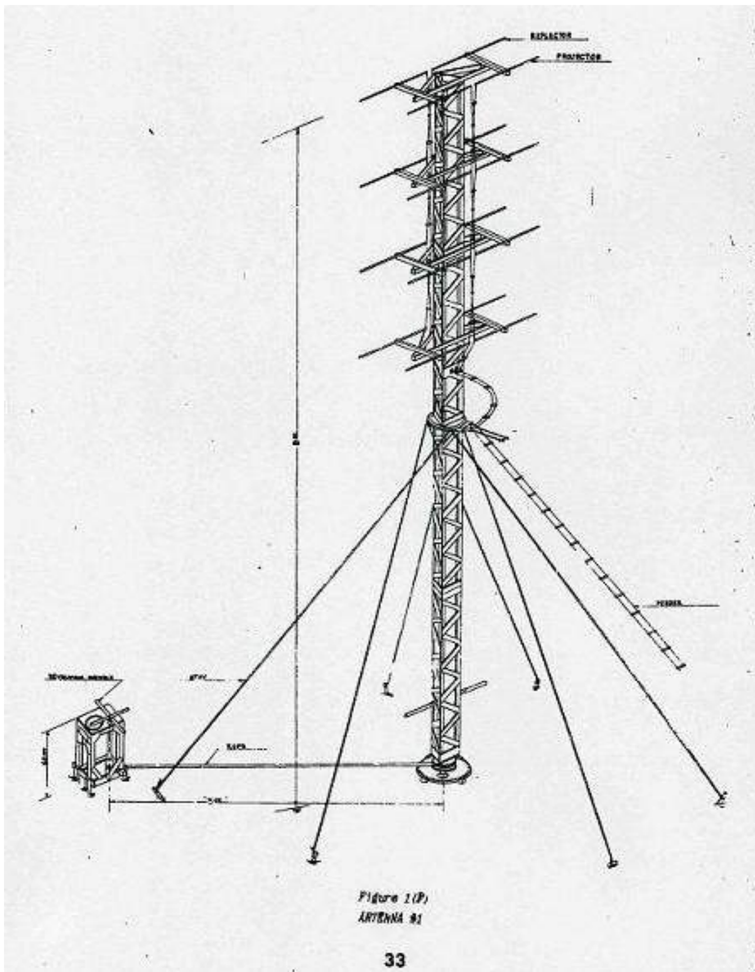


Figure 8. Japanese Mark 1 Model 3 surface and aerial search radar (US Naval Technical Mission to Japan 1946a:33).

4.1.4. Japanese Mark 4 Model 3 Fire-control Radar

The Japanese Mark 4 Model 3 or Type 43 radar was a fire-control module that enabled the detection of enemy aircraft's azimuth, elevation, and speed where that information was relayed to a nearby anti-aircraft batteries (Figure 9). The fire-control radar was directly wired into a director or early computer through which firing solutions were created. The firing solutions were then automatically relayed from the director through a data cable to three to six medium to heavy anti-aircraft gun emplacements to accurately shoot down US aircraft (Figure 10). The radar required four operators at the transmitter location: one to operate the cross arm of the antenna, one to monitor the elevation scope, one to monitor the range scope, and one to monitor the distance scope, with likely an additional officer on radio comms to relay the information to higher command and additional AA emplacements not directly wired in (Nippon Hoso Kyokai (NHK) 1944). The adjacent AA battery and receiver/searchlight of the radar would be automatically controlled and linked to the transmitting radar, where they would be automatically directed (Office of the Chief Signal Officer, Section 22 1945c). The attached AA battery would merely need to load and fire their guns as they would be aimed and fused automatically from data from the radar receiver to the fire-control computer to the guns, enabling deadly accuracy.

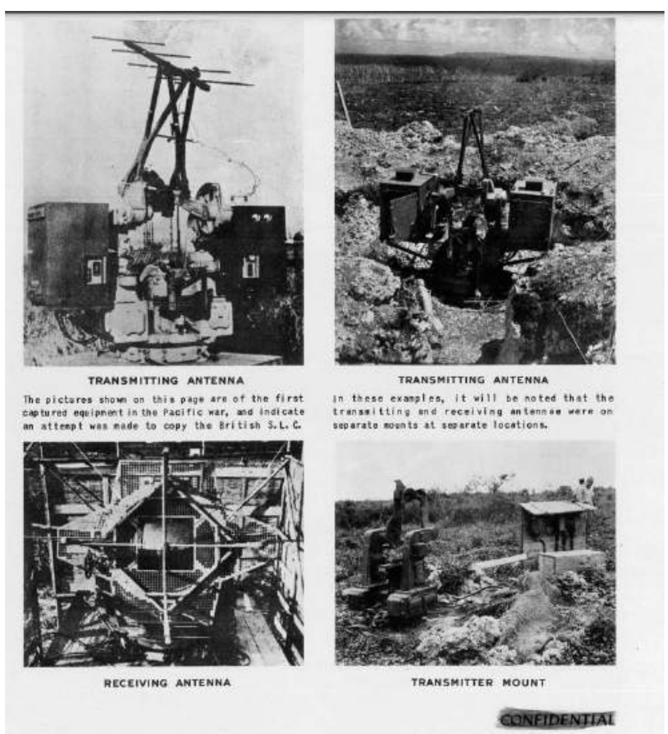


Figure 9. Japanese Mark 4 Model 3 fire-control radar (Division of Naval Intelligence 1945:22).

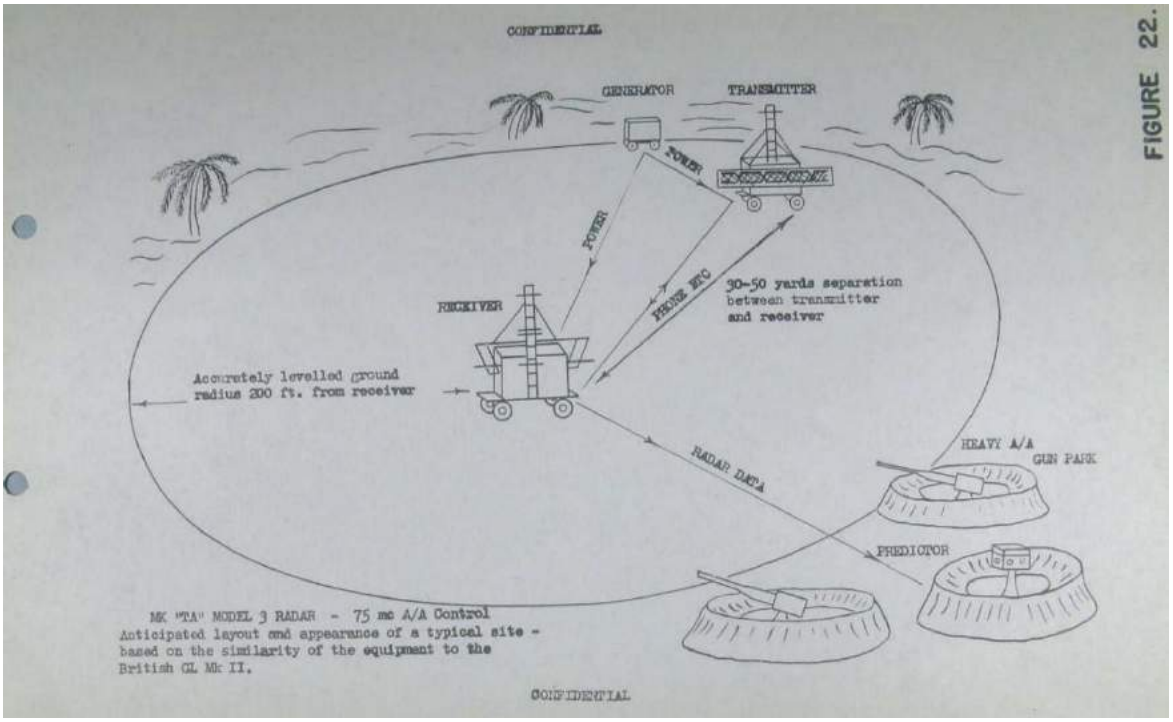


Figure 10. Japanese fire-control radar system fundamentals with AA guns (Office of the Chief Signal Officer, Section 22 1945d:44).

The Japanese radar was developed from a British searchlight control radar (SLC) captured in Singapore in April 1942. The captured SLC radar was a monostatic radar with a Yagi antenna mounted on a searchlight that allowed it to transmit and receive radar pulses (Division of Naval Intelligence 1945). The Japanese modified the British SLC radar variant into a bistatic one where the transmitting element was a Yagi antenna mounted on an elevated cross arm. The transmitting mount also includes a seat for an operator and equipment to enable the angled antenna to tip up and down and enable 360-degree coverage. The receiving element of the radar was four Yagi antennas mounted on a Type 96 110 cm. searchlight. This is because the fire-control radar additionally operated with a searchlight function at night. It was often operated with a blue-colored filter so all anti-aircraft defenses could clone their fire off the accurate radar module. The module weighed approximately 1,000 lbs. and the range of aircraft detection was 40 km. for formations of aircraft and individual aircraft where it operated off a frequency of 200

MHz. (Bonham and Lonsdale 1945:5). The Mark 4 Model 3 L1 went into operation in September 1943 and the improved accuracy of the L2 model came into operation in February 1944 (Wilkinson 1946c:49).

A Mark 4 Model 3 fire-control radar was intended to be placed at Truk Atoll, but the Japanese vessel carrying the radar was sunk by a US submarine in November 1943 (United States Strategic Bombing Survey 1947:7). The lack of this radar at Truk enabled a devastating defeat, as US aircraft were able to surprise attack Japan's "Pearl Harbor" with catastrophic results flying below Truk's search radar emplacements in Operation Hailstone on 17-18 February 1944 (Stewart 1985:107). With the threat of Truk terminated, the American Task Force 58 had a clear route of attack to Saipan.

The discovery of the Mark 4 Model 3 fire-control radar at Saipan was the first Japanese fire-control radar uncovered by US Naval Intelligence. The model found on Saipan was then rapidly shipped to the Naval Research Laboratory in Washington DC, as US Naval Intelligence was concerned about the effectiveness of this fire-control radar and that the US military had underestimated the capabilities of Japanese radar technology (Bonham and Lonsdale 1945). At the Naval Research Laboratory, jamming countermeasures were developed and employed with the B-29 Superfortress bombing missions over Japan from the middle of June 1945 until the war's end. Unfortunately, before the mass employment of countermeasures for the Mark 4 Model 3 fire-control radar, its guidance of anti-aircraft guns downed countless US aircraft, particularly during the low-altitude B-29 Superfortress firebombing raids over mainland Japan. Japanese radar even picked up the B-29 Superfortress atomic bomb missions over Hiroshima and Nagasaki, but due to the small number in the formation and their elevation, no effort was made to intercept them (Figure 11). A total of approximately 240 Mark 4 Model 3 fire-control radars were produced by Japan throughout the war (Wilkinson 1946c:49).

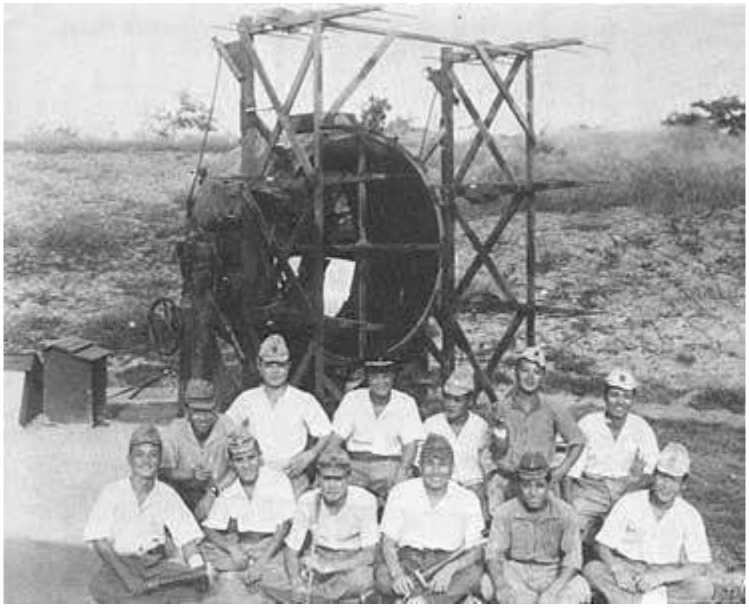


Figure 11. Mark 4 Model 3 fire-control Japanese radar, Nagasaki (Navy Operations Specialist School Graduation Association 1980:230).

4.1.5. Japanese Mark 6 Model 4 Type 3 Airborne Search Radar

Captured on Saipan on Aslito Airfield on 18 June 1944 was a Japanese Mark 6 Model 4 Type 3 or Type H-6 airborne search radar (Figure 12). Saipan was the first time that US Intelligence learned that the Japanese had the capabilities of a fire-control radar but an airborne search radar as well (Headquarters, Expeditionary Troops, Task Force Fifty-Six 1944:5). The Type H-6 airborne search radar was fitted to the Japanese Nakajima B5N or “Kate” torpedo bomber to primarily act as a night scout and enable it to detect Allied submarines and destroy them through their torpedo armament. On Saipan, the Nakajima B5N was likely coordinated with the fixed Mark 1 Model 1 radar emplacements on Naftan Peninsula and Radar Hill and further zeroed in on target with its H-6 airborne search radar. The radar consisted of two 5 ft. dipoles on the front wings of the aircraft as well as two 8 ft. dipoles on the sides of the fuselage

(Division of Naval Intelligence 1945:20). It operated off a frequency of 150 MHz. and had a range of 55 nm. (Division of Naval Intelligence 1945:20). The radar had been operational since August 1942 but had only seen mass employment in late 1944, likely through fears the US would uncover their location through it as the Japanese had done with the Mark III IFF (Nakajima 1992:21). The US Mark III IFF operated on a frequency range from 157-187 MHz. while the Japanese Mark 6 Model 4 Type 3 operated at 150 MHz. with both having an additional frequency variance of approximately ± 5 MHz. (Nakagawa 1998:91). A frequency range often bleeds into another range through radio harmonics, meaning the US Mark III IFF would be transmitting signals to the Japanese Mark 6 Model 4 Type 3 radar at 152-155 MHz.

Figure 12. First captured B5N "Kate" equipped with H-6 airborne search radar off Aslito Airfield (World War Photos 2023).

When captured, like the fire-control radar, it was rushed back to the US for technical capability testing and to develop jamming countermeasures (Figure 13). The discovery of the first Japanese airborne radar and fire-control radar on Saipan came as a great shock to US Intelligence that the Japanese had these advanced radar capabilities. That Imperial Japan had employed the newest technological radar innovations on Saipan is a testament to the island's importance, as it acted as the lynchpin of their established defensive perimeter around the Japanese home islands. Japan produced approximately 2,000 Mark 6 Model 4 radars throughout the war and was the only Japanese airborne radar deployed in combat operations (Nakagawa 1998:91).

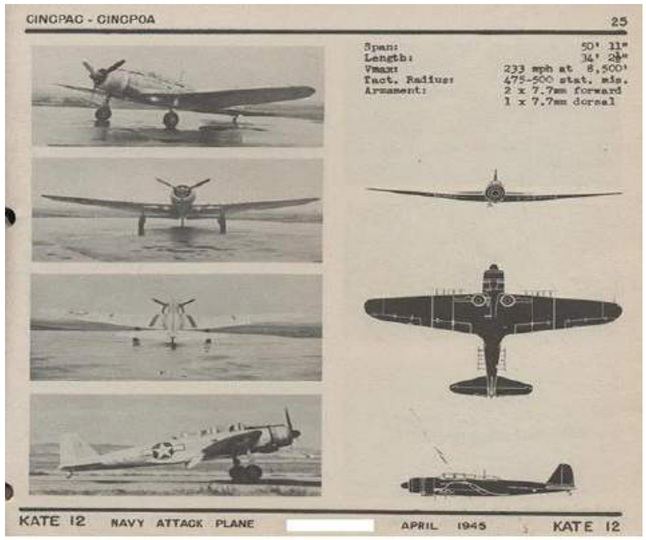


Figure 13. Captured B5N "Kate" equipped with H-6 airborne search radar painted in US colors for analysis (U.S. Pacific Fleet, and Pacific Ocean Areas (CINCPAC-CINCPOA) 1944b:25).

4.2. US Aircraft

During the battle for Saipan, a variety of US Navy aircraft were employed over the island. Of which, 81 were downed in the vicinity of Saipan from 11 June 1944 to 9 July 1944 (Appendix A). Sixteen of these aircraft have Japanese AA being directly mentioned as their loss circumstance in US downing reports (Appendix A). The US combatant aircraft utilized in the battle and analyzed in this thesis are the Grumman F6F-3 Hellcat (23), Douglas SBD-5 Dauntless (7), Grumman TBF Avenger (10), General Motors TBM Avenger (22), Stinson OY-1 Sentinel observation plane (2), and the Grumman FM-2 Wildcat (12) (Appendix A). Additionally lost in a noncombatant role were the Martin PBM-3(D) Mariner (3) and the Curtiss SOC-1 Seagull (1) (Appendix A).

4.2.1. US Grumman F6F-3 Hellcat

The Grumman F6F Hellcat carrier-based aircraft was first produced in 1943 (Figure 14). Its production had been in development by Northup Grumman since 1938 as a replacement for the slower and less powerful F4F Wildcat. The development of the F6F Hellcat was effectively enabled through analysis of a captured Japanese Mitsubishi A6M Zero to negate all the advantages of the Zero and its ability to dogfight through its maneuverability individually. A Pratt & Whitney R-2800 Double Wasp 18-cylinder engine powered the F6F Hellcat (Graff 2009:32). Its armament consisted of six .50 caliber machine guns with 400 rounds of ammo per gun and was capable of carrying up to 4,000 lbs. of bombs (Polmar and Genda 2006:356-357). Most notably added to the F6F Hellcat was the comprehensive use of armor plating to protect the aircraft and the pilot. The armor comprised 212 lbs. of cockpit armor and a bullet-resistant windshield (Campbell 2011:232). A self-sealing fuel tank was additionally used to prevent fuel from leaking or igniting after being hit by enemy fire. The aircraft had a maximum speed of 376 mph. at 23,400 ft. with a considerable operating range of 945 mi. (Polmar and Genda 2006:356). These range capabilities of a single-engine carrier-based fighter made even more reason for the Japanese to encourage the development of their early warning search radars. The comprehensive 212 lbs. of armor of the F6F Hellcat and the heavy armor of Allied later war aircraft further encouraged the development of Japanese fire-control radar. During the battle for Saipan, the F6F Hellcat was the most extensively used aircraft for the initial aerial bombardment and supporting operations. A total of 23 F6F-3 Hellcats were downed over Saipan and the nearby area from 11 June 1944 to 9 July 1944 (Appendix A).

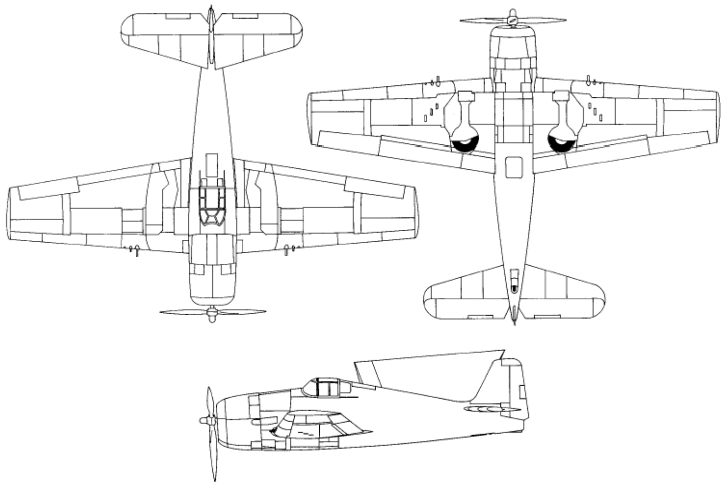


Figure 14. Airframe of F6F Hellcat (top, bottom, side) (The Blueprints 2023a).

4.2.2. *US Douglas SBD-5 Dauntless*

The Scout Bomber Douglas (SBD)-5 Dauntless naval scout plane and dive bomber was first produced in 1940 (Figure 15). Nicknamed “Slow But Deadly,” the aircraft was developed primarily as a dive bomber due to maneuverability and stability in its bombing operations, albeit at slower speeds. A Wright R-1,820 Cyclone 9-cylinder engine powered the SBD-5 with a speed of 255 mph. at 14,000 ft. (Pęczkowski and Juszczak 2007). Its armament consisted of two .50 caliber machine guns in the engine cowling of the aircraft and two .30 caliber machine guns in the rear mount, being capable of carrying up to 2250 lbs. of bombs (Pęczkowski and Juszczak 2007). Its armor consisted of 176 lbs. of cockpit armor with a bullet-resistant windshield, and like most Allied aircraft, the SBD-5 also had a self-sealing fuel tank (Pęczkowski and Juszczak 2007:9). Its operating range was considerable at 1,205 mi., deservedly earning its role as a naval scout plane. A total of 7 SBD-5 Dauntless aircraft were downed over Saipan and the nearby area from 11 June 1944 through 9 July 1944 (Appendix A).

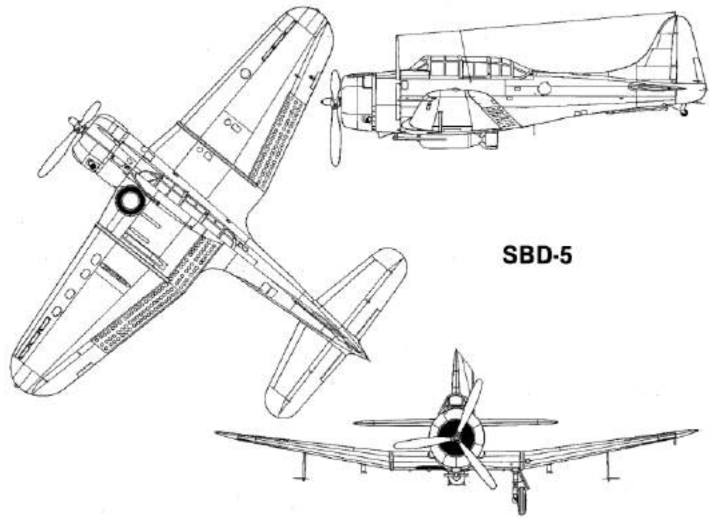


Figure 15. Airframe of Douglas SBD-5 Dauntless (bottom, front, side) (The Blueprints 2023b).

4.2.3. US *Grumman TBM and General Motors TBF Avenger*

The TBM/TBF Avenger torpedo bomber was first produced in 1942 (Figure 16). Two different companies manufactured the aircraft type. Northup Grumman made the TBF, while General Motors made the TBM, and the quality of both remained similar. Nicknamed "Turkey," the aircraft was developed to replace the more sluggish and less maneuverable Douglas TBD Devastator torpedo bomber. A Wright R-2600 Twin Cyclone 14-cylinder engine powered the TBM/TBF (Lepage 2020:258). Its later variant armament consisted of two .50 caliber machine guns, one dorsal-mounted .50 caliber machine gun, and one .30 caliber machine gun and was capable of carrying up to 2,000 lbs. of bombs and torpedoes (Lepage 2020:258). The TBM/TBF utilized considerable armor plating for the aircraft and had a self-sealing fuel tank. Its maximum speed was 267 mph. at 16,000 ft. with an operating range of 1,000 mi. (Lepage 2020:258). Again, the excellent range capabilities and armoring of the TBM/TBF and almost all US aircraft provoked the essential value in Japanese early search warning radar detecting them and the fire-control radar locking into and destroying them. A total of 23 TBM and 10 TBF Avengers were downed over Saipan and the nearby area from 11 June 1944 to 9 July 1944 (Appendix A).

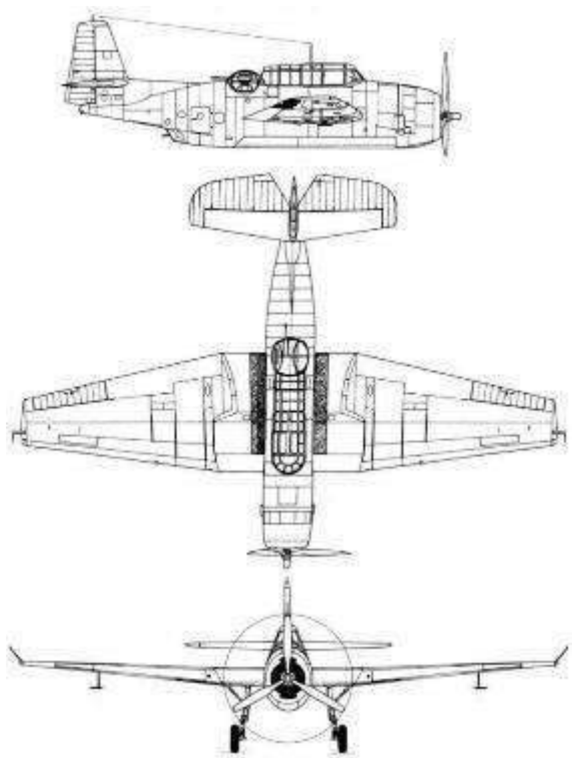


Figure 16. Airframe of Grumman TBF Avenger (side, top, and front view) (The Blueprints).

4.2.4. US GRUMMAN FM-2 WILDCAT

The Grumman FM-2 Wildcat was an antiquated aircraft by the battle for Saipan, having been designed in 1936 and brought into production in 1940 (Figure 17). The FM-2 was the most produced variant of the Wildcat by Northup Grumman. The Wildcat was powered by a Wright Cyclone R-1,820 9-cylinder engine (Smith 2014:158). Its armament consisted of four .50 caliber machine guns and could carry two 250 lb. bombs (Smith 2014:158). The aircraft had a speed of 332 mph. at 28,000 ft. with an operating range of 900 mi. (Smith 2014:158). Twelve FM-2 Wildcats were downed over Saipan and the nearby area from 11 June 1944 to 9 July 1944 (Appendix A).

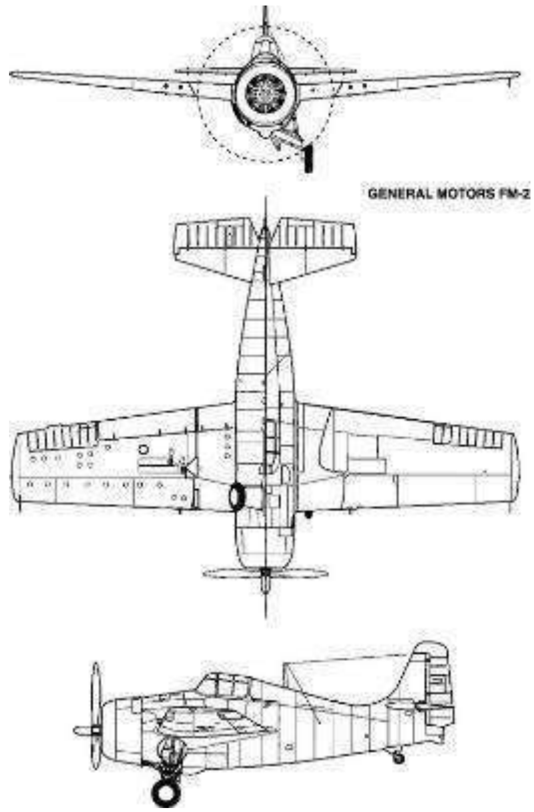


Figure 17. Airframe of Grumman FM-2 Wildcat (front and top view) (The Blueprints).

4.3. Japanese Anti-Aircraft Weaponry

Japanese anti-aircraft guns had quite an infamous reputation for being inaccurate during the early years of the Second World War. These inaccuracies were not often through the guns themselves but rather the lack of research and development into fire-control directors or computers that would help predict and lead an enemy aircraft at a given altitude, elevation, and azimuth (Office of the Chief of Naval Operations 1945b:78). Additionally, there was an overconfidence in the capabilities of the aircraft of Imperial Japan and the belief that they could primarily be utilized as air defense rather than anti-aircraft emplacements. The Mitsubishi A6M Zero, though, had become almost tactically useless with the development of the F6F-3 Hellcat, and by 1943, Japan knew it had lost the air war with the US. Thus, in 1943, an attempt was made to pivot to the purely defensive capabilities of anti-aircraft weaponry (General Headquarters, United States Army Forces 1946). The following anti-aircraft variants were all utilized in the Japanese air defense of Saipan.

Light Japanese anti-aircraft weaponry was utilized heavily in every Japanese anti-air defense throughout the war. There was no use of a fire-control director or radar to coordinate the fire of light anti-aircraft guns and each emplacement was fired manually. Though under 6,000 ft., the gun proved formidable against US aircraft, and the strafing and dive-bombing altitudes were much lower than that (General Headquarters, United States Army Forces 1946). The Japanese most used light anti-aircraft gun was the Type 98 20 mm. AA machine cannon (Figure 18). It had a rate of fire of 300 rounds per minute cyclically and was fed with 20-round magazines (General Headquarters, United States Army Forces 1946:66). It fired a 20 mm. round, had a muzzle velocity of 2,700 ft. per second, and had a maximum aerial ceiling range of 11,000 ft. (General Headquarters, United States Army Forces 1946:66).

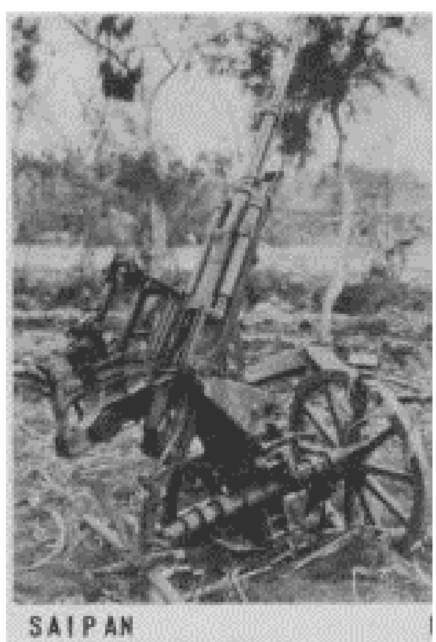


Figure 18. Type 98 20 mm. AA gun captured on Saipan (Office of the Chief of Naval Operations 1945b).

Medium Japanese anti-aircraft weaponry was more accurate as most emplacements were wired directly into a fire-control computer, but the Type 96 25 mm. AA gun was the exception (Figure 19). This gun was based on the French Hotchkiss 25 mm. anti-aircraft gun and was infamous for its inaccuracies (Friedman 2014:148). Its elevation and traverse mechanisms were slow, the gun's firing vibrated the gun and further destabilized its accuracy, its sight was ineffective at high speeds, and it was fed a 15-round magazine by hand. It could fire 200-260 rounds per minute cyclically with a muzzle velocity of 2,700 ft. per second with a maximum ceiling of 18,000 ft. at 85 degrees (General Headquarters, United States Army Forces 1946:66). Still, due to its inaccuracies, it could only be relied on at hardly 3,280 ft. or less (General Headquarters, United States Army Forces 1946:66). Again though, this was still within most of the US aircraft operational altitudes bombing and strafing Japanese defenses. These inaccuracies prompted the development of an effective fire-control radar.

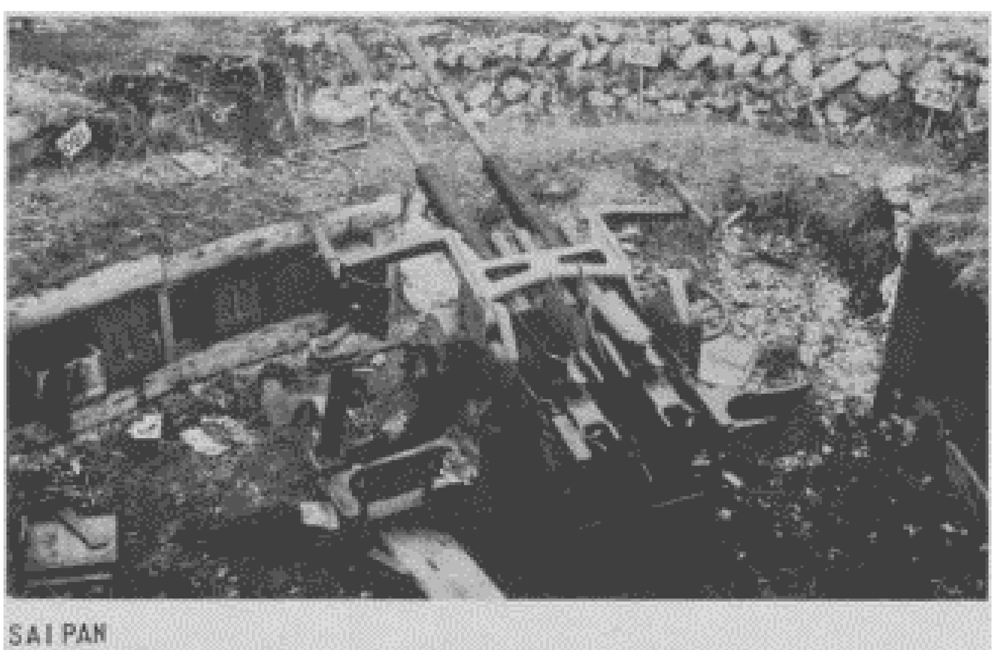


Figure 19. Type 96 25 mm. AA gun captured on Saipan (Office of the Chief of Naval Operations 1945b).

An exceptionally effective medium anti-aircraft weapon for Imperial Japan was the Type 88 75 mm. AA gun (Figure 20). Although the gun was developed in 1927, it remained relevant and accurate through the early years of the Second World War (General Headquarters, United States Army Forces 1946:72). Like the Type 96, though, it could not keep up with the speed of US aircraft even with the help of fire-control directors (Office of the Chief of Naval Operations 1945b). It could fire 10-15 rounds per minute with a muzzle velocity of 2,400 ft. per second (General Headquarters, United States Army Forces 1946:73). The gun fired a 75 mm. round and could reach a maximum ceiling of 29,849 ft. (General Headquarters, United States Army Forces 1946:23).

Figure 20. Type 88 75 mm. AA gun captured on Saipan (Office of the Chief of Naval Operations 1945b).

The Type 10 120 mm. AA gun was the most effective heavy anti-aircraft emplacement, which was heavily utilized in the defensive works on Saipan (Figure 21). The Type 10 was initially developed in 1921 for naval roles but was quickly added to land defenses (Office of the

Chief of Naval Operations 1945b:264). It was only in 1944 that the effectiveness of this anti-aircraft gun was fully realized, when the Japanese extensively produced the Type 10, with its effective pairing of the Type 2 Model 1 fire-control director or computer that assisted in predicting its fire location on a target (Figure 22). Towards the later years of the war, most medium-heavy Japanese AA guns were equipped with new accurate fire-control computers, and with a fire-control radar, the accuracy of AA was increased exponentially. The gun could fire 10-12 rounds per minute with a muzzle velocity of 2,710 ft. per second (Office of the Chief of Naval Operations 1945b:264-265). The gun fired a 120 mm. round and could reach a ceiling range of an impressive 33,000 ft. at 75 degrees, capable of even hitting the US B-29 Superfortress aircraft at its standard operating altitude (1945b:264-265).

Figure 21. Type 10 120 mm. AA gun captured on Saipan (Office of the Chief of Naval Operations 1945b).

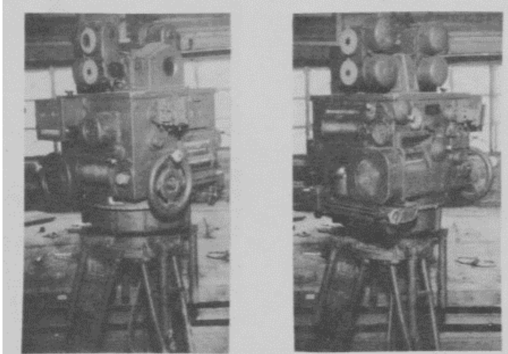


Fig. 42.
Type 2 Model 1,
Front and Left Panels

Fig. 43.
Type 2 Model 1,
Rear and Right Panels

(2) These directors were used with both the 75-mm Type 88 and the 88-mm Type 99 guns. The traverse was limited to between 3 and 5 revolutions in either direction because of the lack of slip-rings. The accuracy of the output data remained approximately the same as that of the old Type 90.

Figure 22. Type 2 Model 1 fire-control director or computer commonly used with medium and larger Japanese AA guns (Office of the Chief of Naval Operations 1945b).

The primary anti-aircraft gun utilized on Radar Hill that was likely directly wired in and coordinated through the Mark 4 Model 3 fire-control radar was the Type 3 80 mm. AA gun (Figure 23). A battery of three of these remarkably effective guns appears to have been employed on Radar Hill. It likely may be the anti-aircraft gun battery that struck down the multiple submerged US aircraft in Tanapag Harbor. The Type 3 was one of the most accurate anti-aircraft weapons of the IJN (US Naval Technical Mission to Japan 1946c:28). It could fire 13-20 rounds per minute with a muzzle velocity of approximately 2,250 ft. per second with an 18,000 ft. ceiling range at 75 degrees (US Naval Technical Mission to Japan 1946c:28).

One (1) gun of battery of three (3) 80mm antiaircraft guns on high ridge 3000 yards east of FLORES POINT, (coordinates 12.1-27.6).

Figure 23. Type 3 80 mm. AA gun captured on Saipan (Engineer, Expeditionary Troops (Task Force 56) 1944:72).

Although never installed at its emplacements on the Naftan Peninsula, the 127 mm. Type 89 dual-purpose AA and artillery guns were intended to be employed to defend the radar on the Naftan Peninsula (Figure 24). Like the Type 10, it was initially developed for naval roles but adapted for land defenses. The Type 89 was developed in 1928 and could fire 8-14 rounds per minute with a muzzle velocity of approximately 2,380 ft. per second and a ceiling of 30,840 ft. at 75 degrees.

Figure 24. 127 mm. Type 89 dual-purpose AA and artillery gun (Office of the Chief of Naval Operations 1945b).

4.4. Japanese Radar at the Battle for Saipan

The four currently known radar transmitting units active on the island provided a triangulated and overlaying secure defensive network. Saipan acted not only as the lynchpin of Imperial Japan's defensive perimeter but as an essential element to a more extensive search warning radar network that protected mainland Japan from a surprise attack by US forces. Search warning radars were established in the Mariana Islands on Guam, Rota, Tinian, Saipan, and Pagan, acting as an overlapping wall of detection in the Central Pacific. Saipan was the most built up of this radar network, utilizing multiple varying radar modules. Varying reconnaissance missions were conducted on Saipan before the US invasion on 11 June 1944.

Notably, the submarine *Whale* conducted a submerged survey on 10 March 1943 (Lotz 2018:102). Eight vessels in anchor were observed, with considerable aircraft and vessels patrolling around the island. Seaplanes were seen launching from the harbor as a sign *Whale* was detected on radar (Lotz 2018:102-103). Multiple air and surface search radar emplacements were observed, and photographs were taken around the island. An air search radar was observed on the mountaintops of the island. The emplacements observed were likely the ones on Radar Hill and the dummy radar emplacement located on Mount Petosukura northeast of the island. A surface search radar was additionally observed on Mañagaha Island. This radar is believed to be the Mark 1 Model 3 search radar. The mobile radar was ideal for detecting maritime vessels in a potential invasion and submarines that would attempt to sneak into the harbor for surveillance, such as *Whale* was doing (Lotz 2018:45). The Mañagaha Island radar emplacement was observed rotating 360 degrees every 15 seconds through period interference on *Whale's* own SD radar receiver (Lotz 2018:103). A Japanese torpedo boat and aircraft were employed unsuccessfully to locate *Whale*, likely having been alerted by the radar emplacements. Additionally, further reconnaissance was conducted off Tanapag Harbor and Saipan from 17 April 1944 to 22 April 1944, where at the surface, it again received interference on its radar receiver and was detected by Japanese radar on Saipan (Lotz 2018:248), likely having been detected by the Mañagaha radar emplacement.

US aerial reconnaissance observed the sites on the 22 February 1944 raid over the island where the Naftan Peninsula radar emplacement was noted (Hallas 2019:21). The raid fleet was additionally intercepted before they reached Saipan, where radar likely notified the Japanese defenses. During this mission, four F6F-3 Hellcats and one TMB-1C Avenger were shot down by anti-aircraft fire, but vital photographic intelligence was gained over the island (Appendix A). Additional reconnaissance missions were conducted throughout April and May to get a more comprehensive picture of the defenses on the island. Notably, on 29 May 1944, the B-24 Liberator *Cloudy Joe* was downed by Japanese aircraft 25 mi. from Saipan after conducting photographic reconnaissance of the island. The surviving crew was picked up by the Japanese and brought back to Saipan, where they were interrogated heavily on how they made it to Saipan without being detected by their radar emplacements. Through interrogation, it was determined the US aircraft deployed chaff, or reflective aluminum strips, to obscure the radar en route to Saipan (Hallas 2019:51). Chaff was not employed by the US invasion aircraft on 11 June 1944. Japanese aircraft would employ chaff throughout the initial stages of the battle but not US forces so as not to likely confuse the radar systems of their invasion fleet.

The air and surface search radar primarily used was the Type 13, also known as the Mark 1 Model 3 or “13-Go” (Nakagawa 1997:62). This radar emplacement was likely located on the eastern approach of Mañagaha and the eastern approach of Aslito Airfield, allowing visibility on both possible US invasion routes (Lotz 2018:198). They likely first became operational around August 1943, with over 1,000 models being produced. It had a detection range for a single aircraft of 50 km. and a detection range for a group of aircraft up to 100 km. (Nakagawa 1997:86). The Japanese Mark 1 Model 3 radar could also detect naval surface vessels and submarines, albeit at shorter ranges. This warning array assured the Japanese defenders of no surprises from the US, as these radar systems would know in advance of an impending attack.

The most advanced radar at Saipan was situated in the island’s mountainous center on *Okso Talofofo*, aptly later named “Radar Hill” by 1-24 Marines who would later capture it (Hoffman 1950:203). The Tanapag and adjacent Radar Hill region of the island were under the command of the IJN, as were all individual radar emplacements on the island (Figure 25). On it was a Mark 1 Model 1 or Type 11 search radar, which allowed long-range detection for a group of aircraft up to 250 km. and a single aircraft up to 130 km. (Nakagawa 1997:86). An additional emplacement was confirmed through a captured August 1943 Saipan radar operation protocol document confirming Mark 1 Model 1 search emplacements on Naftan Peninsula and Radar Hill (Figure 26). These emplacements would rotate hours of operation and readiness priorities to enable 24/7 early warning detection capabilities for Saipan (Figure 27). Its operation was identified during the battle by USS *Alabama*, picking up its frequency interference on its receivers on 12 -13 June 1944 (Figure 28). The Japanese defenders also deployed eight submarines around the waters of Saipan and 21 submarines around the entire Marianas by June 13, 1944, to form a sentry line (Yoshida 1995:141). This action would further assist Japanese detection of the US invasion fleet as each submarine, as of April 1944, was equipped with a Type 13 aerial search radar with a range of at least 100 km. and a Type 22 surface search radar with a range of 35 km. and would have enabled an additional layer of detection (Stille 2012:9). Additionally, a Mark 4 Model 3 fire-control radar was likely located on Radar Hill on Saipan and US intelligence was unaware that the Japanese had gun-laying capabilities via radar. This radar emplacement could communicate with all the anti-aircraft emplacements on the island via transmission data cables to fire directors or radio communications to focus their fire on a single aircraft or aircraft formation with accurate efficiency. The emplacement detected a single aircraft up to 20 km. and aircraft formations up to 40 km. (Wilkinson 1946c:49). It was often paired with a searchlight, enabling the nocturnal direction of anti-aircraft fire against US forces (Nakagawa 1997:33-34).

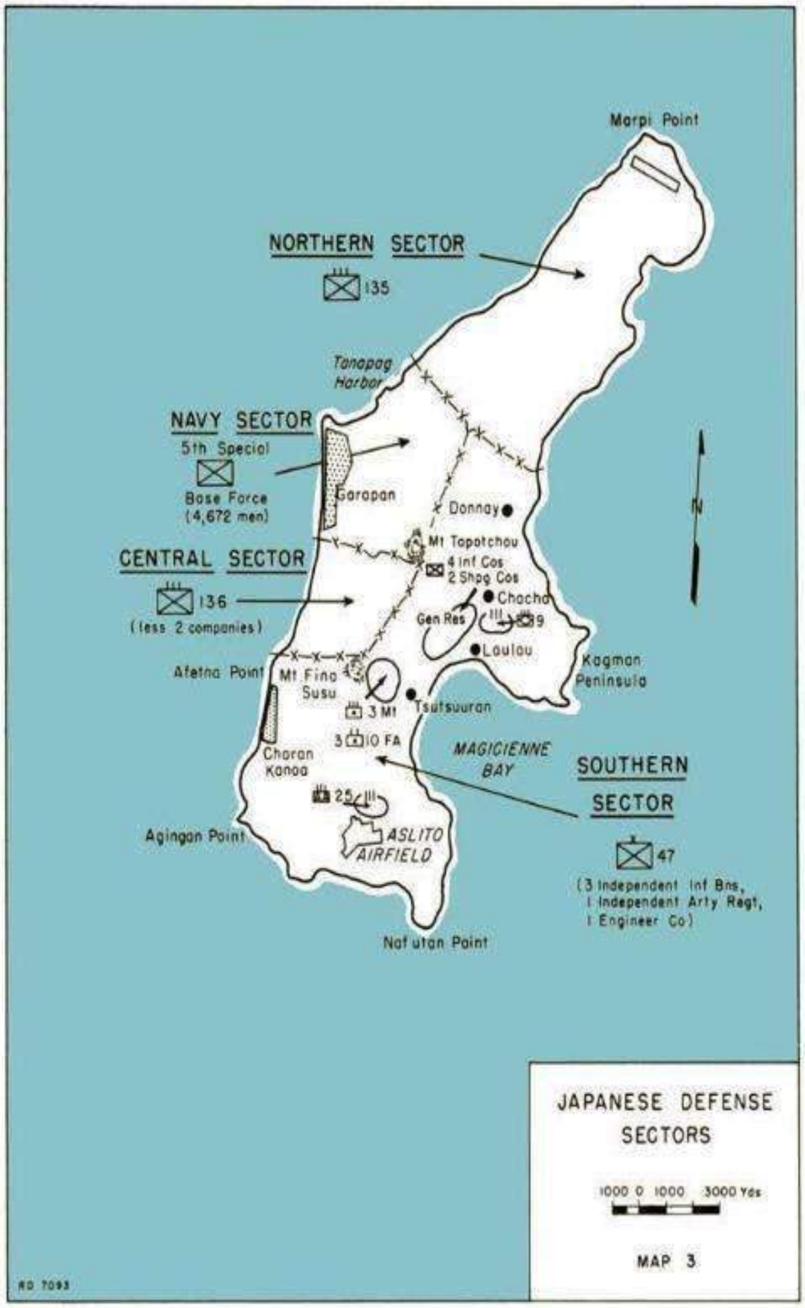


Figure 25. Saipan Japanese Sectors of Defense (Hoffman 1950:13).

CONFIDENTIAL CINCPAC-CINCPOA SPECIAL TRANSLATION CONFIDENTIAL

Item #11,418, page 3

IV. THE COLLECTION OF REPORTS AND OBSERVATIONS

4. The collection of reports shall conform to the following:

UNIT	/UNIT/ RESPONSIBLE FOR COLLECTION	METHOD OF COMMUNICATION
1 - Army Hq	Regtl Hq	Telegraph or Telephone
2 - Naval 5th Base Force Hq		Telegraph or Telephone (Result of search of Naval Radar and also friendly planes)
3 - MT HAGUMAN Observation Party		Wireless
4 - Naval Air Field		Telegraph or Telephone
5 - MT MARPI	7th SL Unit	Telegraph or Telephone
6 - Observation parties of all units	All units	Telegraph or Telephone

Note: The disposition of necessary sky watch areas shall conform to Annexed Map #2.

5. Reports shall be disseminated in accordance with the following:

a. /In communicating the position of enemy aircraft/ reports between companies and battalions and regimental headquarters shall be either by the bearing (in mils), and the angle of sight /from the observation station/, or be the /position/ by map squares and the direction /of flight/.

Each map square shall be 4 kilometers on a topographical map of SAIPAN (scale 1:25,000), with MT TAPOTCHAU (height: 473 meters) as an orientation point.

Grid chart appears as Annexed Table #3.

b. Reports from the 5th Naval Base Force Hq shall be communicated to each unit in the following manner:

Designation of observation party
Time of detection
Bearing (in mils)
Direct range

Figure 26. Captured translated Japanese document: Radar warning regulations for air and surface search (5th Special Base Force), August 1943 (U.S. Pacific Fleet, and Pacific Ocean Areas (CINCPAC-CINCPOA) 1943).

4. Watch periods are as follows:

Classification	DENSHINYAMA	NAFUTAN	Remarks
Condition of readiness #3	0400 to 0800	1700 to 2100	1. Alert stations should be rotated each week. 2. When not on duty the personnel carry on their daily assignments of study, maintenance and handling of equipment.
Condition of readiness #2	0000 to 0500 0800 to 1200 1600 to 2100	0300 to 0800 1200 to 1800 2100 to 2400	1. Alert stations should be rotated each week. 2. When not on duty the personnel shall make all necessary repairs to equipment. 3. When a warning report is dispatched, all personnel go to their stations. Thereafter regular duty watch is resumed on the given command.

No. 11, page 72.

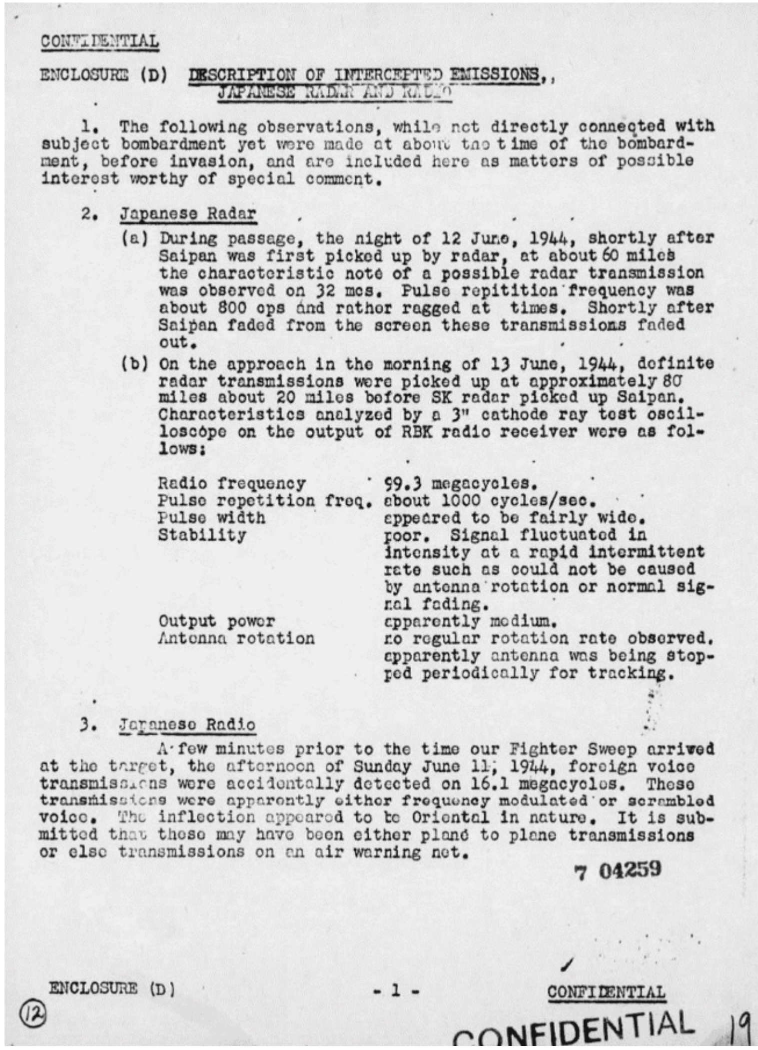
THIS PAGE IS DECLASSIFIED IAW EO 13526

THIS PAGE IS UNCLASSIFIED

Item #12,233, page 3

Classification	DENSHINYAMA	NAFUTAN	Remarks
Condition of readiness #1	0000 to 0600 0800 to 1400 1600 to 2200	0200 to 0800 1000 to 1600 1800 to 2400	1. Same as above. 2. Same as above. 3. Same as above.

Figure 27. Radar operation hours and readiness levels for Naftan Peninsula and Radar Hill/Denshinyama emplacements. (U.S. Pacific Fleet, and Pacific Ocean Areas (CINCPAC-CINCPOA) 1943).



CONFIDENTIAL

ENCLOSURE (D) DESCRIPTION OF INTERCEPTED EMISSIONS,, JAPANESE RADAR AND RADIO

1. The following observations, while not directly connected with subject bombardment yet were made at about the time of the bombardment, before invasion, and are included here as matters of possible interest worthy of special comment.

2. Japanese Radar

(a) During passage, the night of 12 June, 1944, shortly after Saipan was first picked up by radar, at about 60 miles the characteristic note of a possible radar transmission was observed on 32 mcs. Pulse repitition frequency was about 800 cps and rather ragged at times. Shortly after Saipan faded from the screen these transmissions faded out.

(b) On the approach in the morning of 13 June, 1944, definite radar transmissions were picked up at approximately 80 miles about 20 miles before SK radar picked up Saipan. Characteristics analyzed by a 3" cathode ray test oscilloscope on the output of RBK radio receiver were as follows:

Radio frequency	99.3 megacycles.
Pulse repetition freq.	about 1000 cycles/sec.
Pulse width	appeared to be fairly wide.
Stability	poor. Signal fluctuated in intensity at a rapid intermittent rate such as could not be caused by antenna rotation or normal signal fading.
Output power	apparently medium.
Antenna rotation	no regular rotation rate observed. apparently antenna was being stopped periodically for tracking.

3. Japanese Radio

A few minutes prior to the time our Fighter Sweep arrived at the target, the afternoon of Sunday June 11, 1944, foreign voice transmissions were accidentally detected on 16.1 megacycles. These transmissions were apparently either frequency modulated or scrambled voice. The inflection appeared to be Oriental in nature. It is submitted that these may have been either plane to plane transmissions or else transmissions on an air warning net.

7 04259

ENCLOSURE (D) - 1 - CONFIDENTIAL

(12) CONFIDENTIAL 19

Figure 28. Report stating Saipan Japanese search radar emissions from likely Naftan Peninsula or Radar Hill, given its operating frequency of 99.3 MHz., was detected by the USS *Alabama* on June 12-13, 1944 (USS *Alabama* 1944).

4.5. Post-Battle Japanese Radar Countermeasures

Upon the capture of Saipan, the Japanese Mark 4 Model 3 fire-control radar was found to be in a nearly operational state. It is believed this module was located on Radar Hill and was filmed on 22 July 1944, with other radar emplacements (National Archives and Records Administration 1944b). This was the first Japanese fire-control radar discovered by US Intelligence, where the Japanese were unknown to have advanced radar capabilities at the time. The module was disassembled and rapidly shipped back to the US to the Naval Research

Laboratory in Washington, DC, for analysis to determine its operational frequency and develop jamming countermeasures (Bonham and Lonsdale 1945).

L.L. Bonham and E.M. Lonsdale of the Radio Division- Search Radar Section analyzed the Mark 4 Model 3 fire-control radar. The complete radar, minus the receiver mount, was transported to the Naval Research Laboratory after its reported capture in June 1944. An Army Service Forces Enemy Equipment Intelligence Service Team inspected the equipment on 11 September 1944. After its identification, it was shipped to the US two days later. The transmitter and power supply were engraved with its serial number, 13, and manufacture date of February 1944 (Bonham and Lonsdale 1945:1). The module was assigned to the laboratory on 27 November 1944, with defective power-oscillator tubes (Bonham and Lonsdale 1945:27). Potentially, this is what led to the abandonment of the radar by the Japanese on Saipan and would further confirm its location on Radar Hill, with a vacuum tube case believed to have been located at the suspected deployment field. Replacement tubes of Japanese manufacture were located and received on 26 March 1944 (Bonham and Lonsdale 1945:1). The conclusions drawn from the analysis were that the radar module and its detection capabilities were "entirely adequate for a search-light-control radar system with a maximum range of 40,000 yds. if no jamming is encountered and if the system is kept tuned for optimal performance" (Bonham and Lonsdale 1945:7).

Meanwhile, the Japanese had employed dozens of Mark 4 Model 3 fire-control radar units throughout the Japanese Empire, mainly focused on protecting the mainland. By the war's end, approximately 240 units had been produced, taking down countless US aircraft (Wilkinson 1946c:49). Particularly vulnerable was the low-flying firebombing raids that would ravage mainland Japan where 147 B-29 Superfortress were lost to flak and fighters (Nijboer 2018:207).

This destruction was enabled through a comprehensive long-range early warning search radar system that Japan had established primarily by the separate IJA and IJN radar detection command (Wilkinson 1946a). Approaching US aircraft were detected usually over an hour in advance (Wilkinson 1946a:19). The Japanese radar emplacement that detected the aircraft relayed the information through telegraphic wire to the local area where the aircraft were plotted, and a coordinated defense was established where local airfields and air defense units were notified to intercept (General Headquarters, United States Army Forces 1946:221-223).

This detection gave the Japanese fire-control radar and anti-aircraft emplacements time to get to their emplacements with complete readiness. The fire-control radar could then easily lock into and track aircraft of the often-massive bombing formations when they arrived over mainland Japan to concentrate the fire of multiple anti-aircraft emplacements at individual aircraft to down them quicker and more efficiently. At night, through its additional searchlight function, the receiver and searchlight of the radar was fitted with a blue lens filter where dozens of anti-aircraft guns and searchlights could clone off an individual target to destroy the target effectively (Wilkinson 1946a:61). From June 1944, when this fire-control radar was first encountered on Saipan to May 1945, it wreaked havoc on US aircraft.

The only countermeasures employed before May 1945 were electronically locating and physically destroying the fire-control radar. These fire-control radars posed so much of a threat that it caused the expansion of Section 22, General Douglas Macarthur's clandestine radar hunting unit. Section 22 would determine a Japanese radar's operational frequency upon its capture. Then, through Japanese radar detectors and direction-finding equipment on B-25 Mitchell bombers, the unit would locate, map, and bomb the Japanese radar emplacements (Kreis 2013:271-272). Section 22 had been around since July 1943, with US and Australian involvement in hunting Japanese search radars after their shocking discovery on Guadalcanal. Still, it was only in October 1944 that General Macarthur called for the rapid size up of the organization, likely assisted by the fire-control radar discovered on Saipan and the fire-control radar later discovered on Peleliu. The operational frequency of the Mark 4 Model 3 fire-control radar appears to have not yet been determined to be 200 MHz. as the Naval Research Laboratory did not receive the necessary Japanese power-oscillator tubes to determine its frequency effectively (Bonham and Lonsdale 1945).

In March 1945, during B-29 firebombing missions over Tokyo, dozens of B-29s were lost through predominately anti-aircraft fire (Hoyt 2000). By early 1945, Imperial Japan had an extensive early warning search and fire-control radar system, particularly in the Philippines and mainland Japan (Figures 29-32). A total of 147 B-29s were lost during the bombing missions of Japan through enemy combat, mainly through anti-aircraft fire, as Japanese aircraft capabilities were mostly heavily antiquated against US aircraft by 1944 (Nijboer 2018:207). Through the help of the analysis of the captured Japanese fire-control radar from Saipan, in May 1945 B-29 bomber formations were equipped with “porcupines” or “guardian angels.” Multiple dipole antennas attached to the outside of the aircraft, thus their nickname “porcupine.” The APT-1 was the radar barrage jammer commonly used. It was set to transmit the frequencies 185-205 MHz. (common Japanese search radar frequencies) at great power where these “porcupines” would flood the airwaves with electromagnetic radiation (Kuehl 1993:23). Spot jammers like the ARQ-1 were additionally used where a jammer with increased power for increased jamming range targeted specific frequencies, such as for the Japanese fire-control radar (Figure 33). The “porcupines” essentially employed an electromagnetic smokescreen where the radar emplacements could not lock, track, and destroy individual targets, making the radar useless when it was employed. An aircraft formation could also deploy chaff or “window,” where aluminum strips would be deployed by aircraft that would reflect the radar wave frequencies. The radar jamming was so effective that US radar countermeasures officers noted that after the US began employing these radar jammers in the Pacific, the flak damage rate decreased from 60% to a mere 10% flak damage rate by June 1945 (Kuehl 1993:23). This decrease in flak damage and the countless number of aircraft and lives saved was all through the intelligence gained from the Mark 4 Model 3 fire-control radar first captured on Saipan in June 1944.

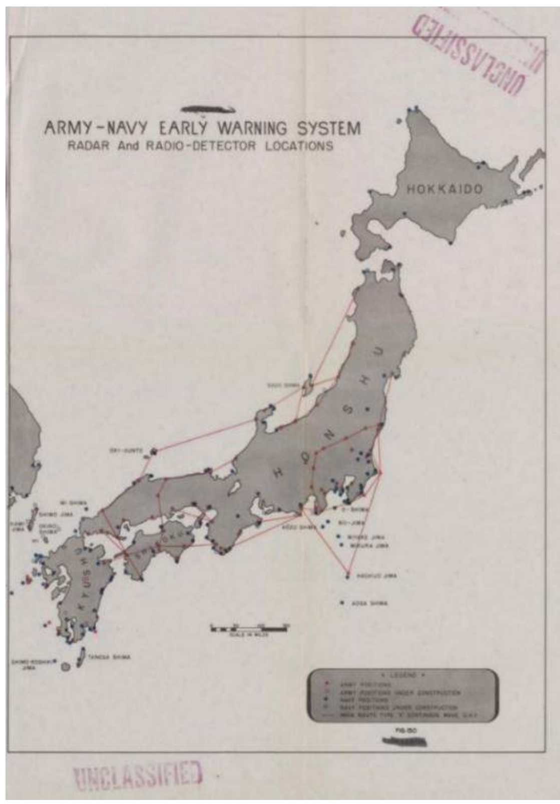


Figure 29. Army-Navy Early Warning Radar System over mainland Japan (General Headquarters, United States Army Forces 1946:220).

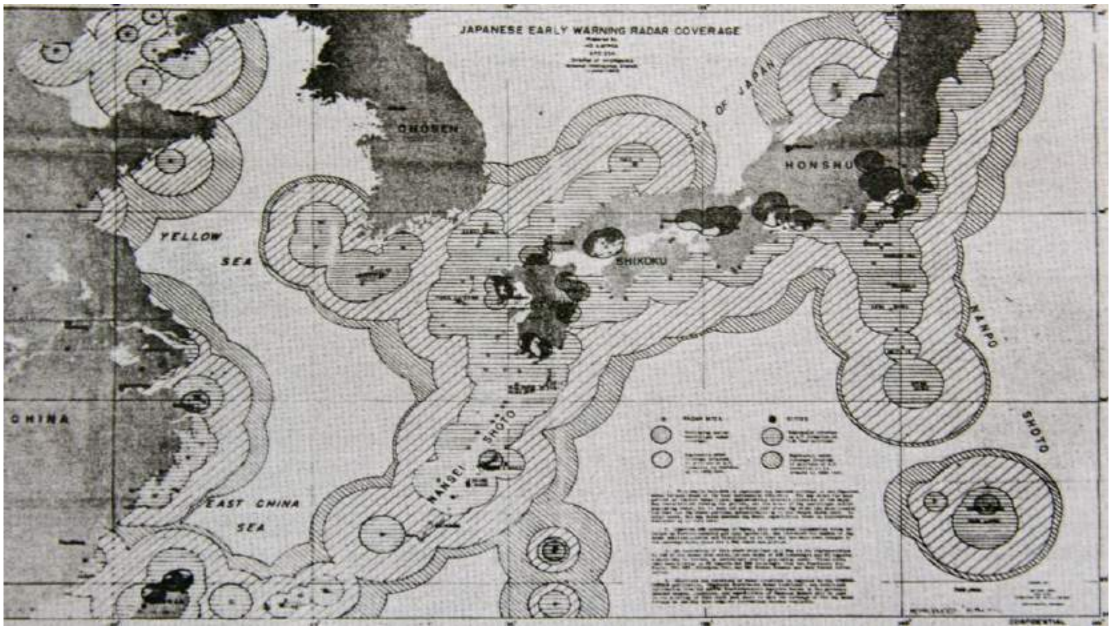


Figure 30. 1945 Japan early warning radar coverage, June 1945 (Office of the Chief Signal Officer, Section 22 1945d).

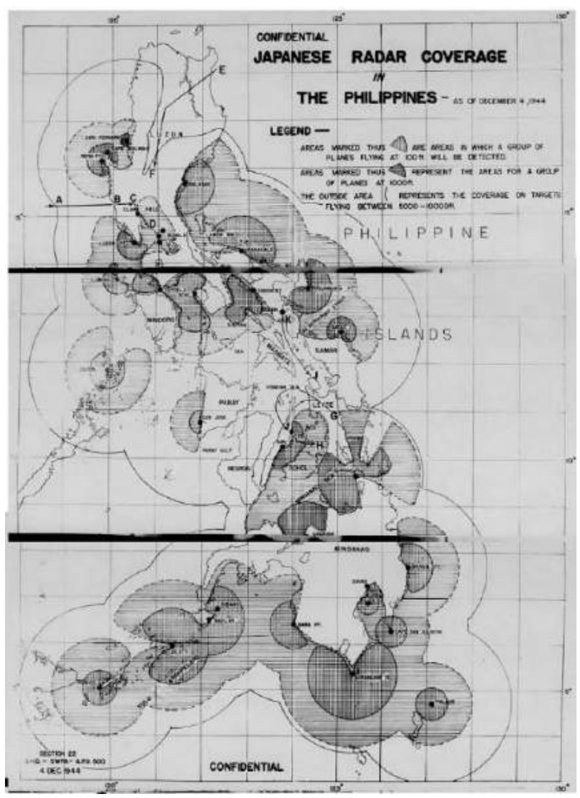


Figure 31. Japan's early warning radar coverage over the Philippines as of December 4, 1944 (Office of the Chief Signal Officer, Section 22 1945d).

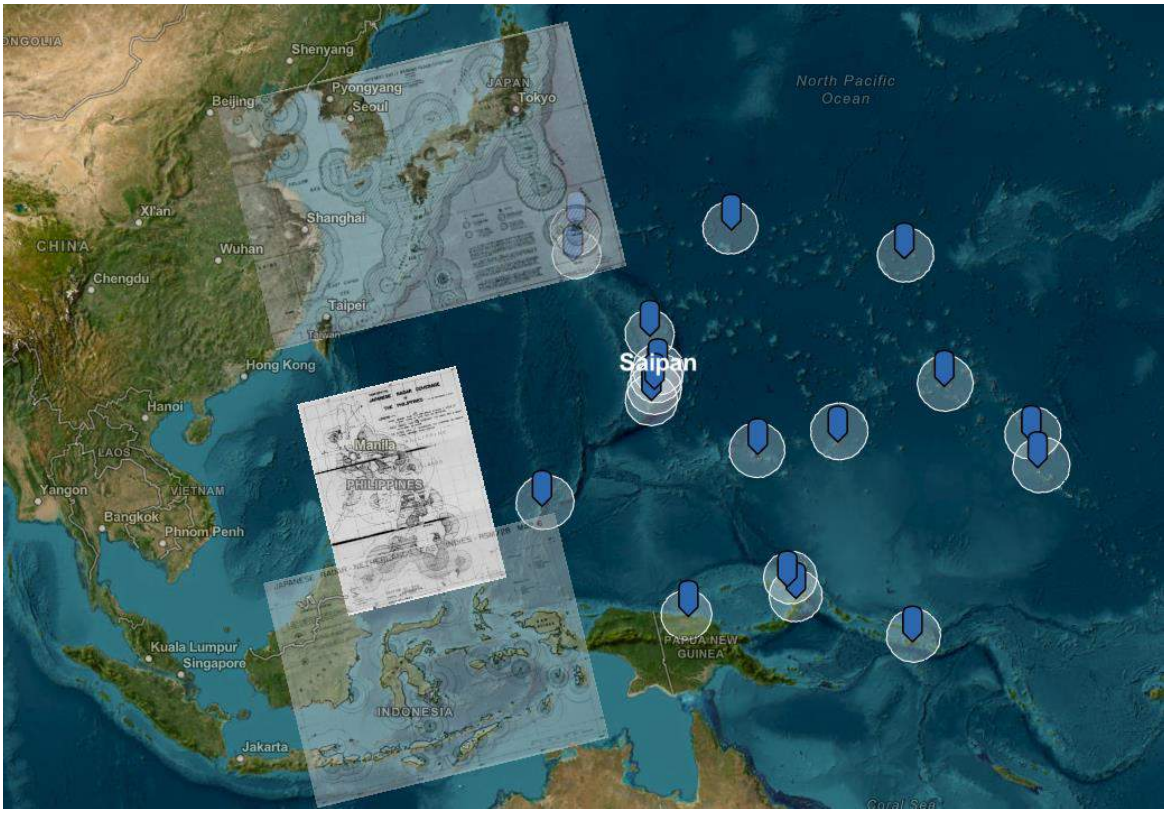


Figure 32. All known Japanese early search warning search radar locations with georectified Section 22 Japanese radar map overlays (Image created by author on ArcGIS).

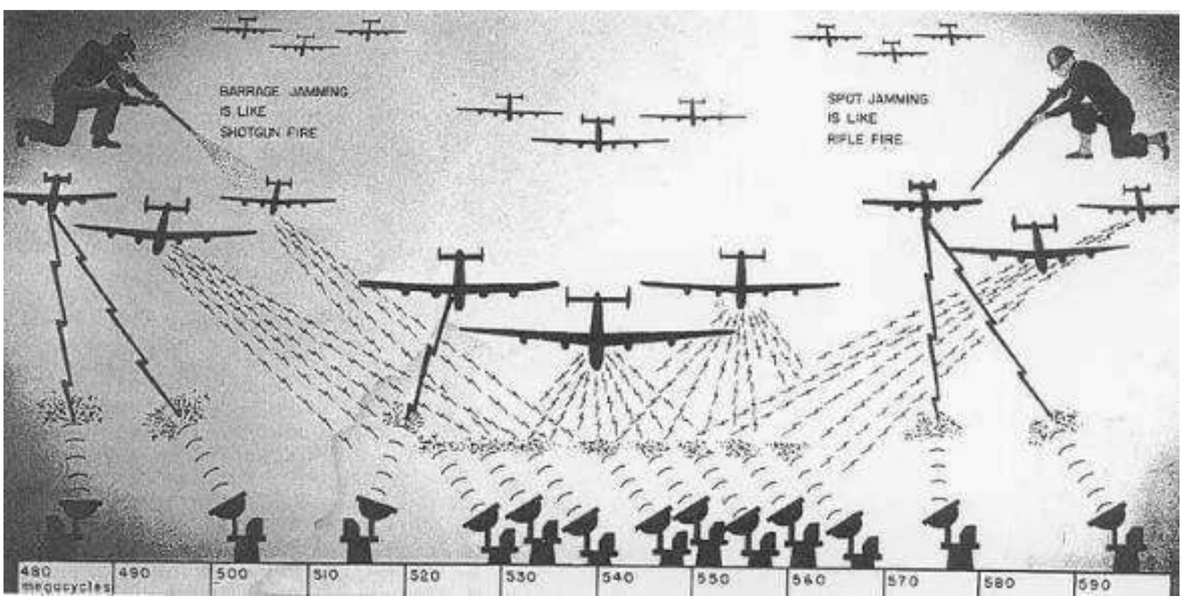


Figure 33. Barrage jamming and spot jamming fundamentals diagram (Foundation for German Communication and Related Technologies 2023).

Through the effectiveness of Japanese radar, post-war, much was clearly concealed by US military leadership. This was conducted by military brass trying to save their careers and to hide flaws in US technology from the Soviet Union during the rising Cold War. The US SCR-584 microwave land-based fire-control radar only replaced the SCR-268 in the Pacific by late 1944 (Brown 1999:72). Through this blunder, the Japanese had equal or even more advanced land-based fire-control radar, especially in the case of the Mark 4 Model 3 fire-control radar, than US land-based fire-control radar. Additionally, the frequency range of the US Mark III IFF was never remedied until 1952 after having continual US aircraft compromised and destroyed in the Korean War when it was finally replaced by the Mark X IFF (Hallion 2011:76). The Mark X operated on single frequencies and the enemy could not trigger the IFF without the proper code. The effectiveness of Japanese radar was hidden from the standard post-Pacific War narrative to cover US technological blunders, having only been remedied nearly a decade after the discovery of its compromised state.

CHAPTER 5 ARCHEOLOGICAL DATA AND ANALYSIS

5.1. RADAR HILL SURVEY

The initial survey conducted in March 2022 was of Radar Hill primarily because of its name and the idea that names can indicate locations of past activities. The site has several names in addition to Radar Hill. In Chamorro, the area is called *Okso Talofofo*, meaning “bubbling spring hill” (Fred Camacho March 2022, pers. comm). The site is also presently called Wireless Ridge. Local guide Fred Camacho believed this name might have originated since scrappers stripped much of the underground copper wiring and cables from the location. The Japanese occupiers called the site *Denshin Yama* or “telegraph mountain.” A telegraph is “any device or system that allows the transmission of information by coded signal over distance” (McGillem 2024). It could refer to the radar itself as the Japanese identified radar as a “wireless telegraph” system throughout the war (Wilkinson 1946a). It was additionally uncovered that Radar Hill was known to locals as Deni Hill, likely from the Japanese etymological origin of the site (Fred Camacho May 2023, pers. comm.). US strategic military planners identified the site as Hill 221, and the site gained its name, “Radar Hill,” from the Marines of Able Company of 1-24 Marines Battalion that captured the site on 3 July 1944 (Hoffman 1950). Multiple radar antennas, such as the Mark 1 Model 1 search radar, were identified on Radar Hill. Thus, the Marines named the hill through these observations (Hoffman 1950:203).

Radar Hill was further determined to be investigated as it was confirmed through captured translated Japanese documents from 1943 that it was the location of a Japanese radar emplacement that coordinated with the Naftan Peninsula radar location. It additionally functioned as the lynchpin of the final Japanese defensive island during the battle (Figure 34).

The US Navy filmed the location on 22 July 1944, which the Naval Photographic Center holds as film #4886. The footage was in the National Archives and titled “Invasion of Saipan: Japanese Radar; Unloading on Pontoon Dock.” The footage shows Radar Hill from 0:00-1:23, where two sets of Japanese radar are shown, presumably the transmitter and receiver of the Japanese Mark 1 Model 1 search radar. Also shown in the footage immediately after the radar is a Japanese searchlight. The searchlight in the reel has the same appearance as the receiver of the Mark 4 Model 3 fire-control radar captured on Saipan.

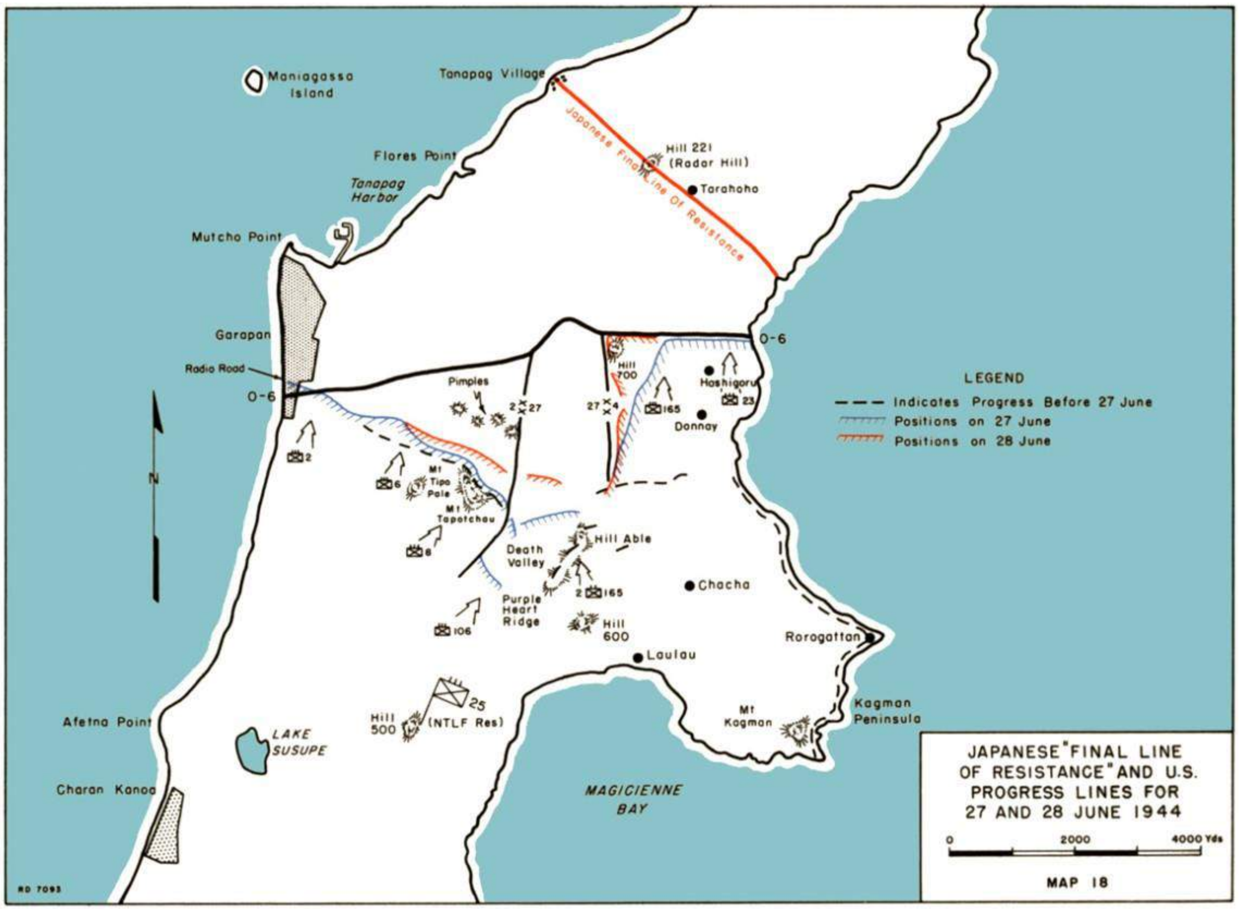


Figure 34. Radar Hill was the linchpin of defenses for Imperial Japan’s final line of resistance as of June 28, 1944 (Hoffman 1950).

A map from these May 1944 reconnaissance flights identified the Japanese defense on Radar Hill containing multiple “strong points” (Figure 35). An intelligence map created from

May 1944 aerial reconnaissance flights identifies the location as being fortified with three automatic AA guns, three single-mount heavy AA guns, and a searchlight, potentially being the Mark 4 Model 3 fire-control radar (Figure 36 through Figure 37). ArcGIS overlays were also used with US Intelligence maps of Japanese defenses on the island, confirming an AA battery and searchlight within .25 mi. of the suspected radar employment field.

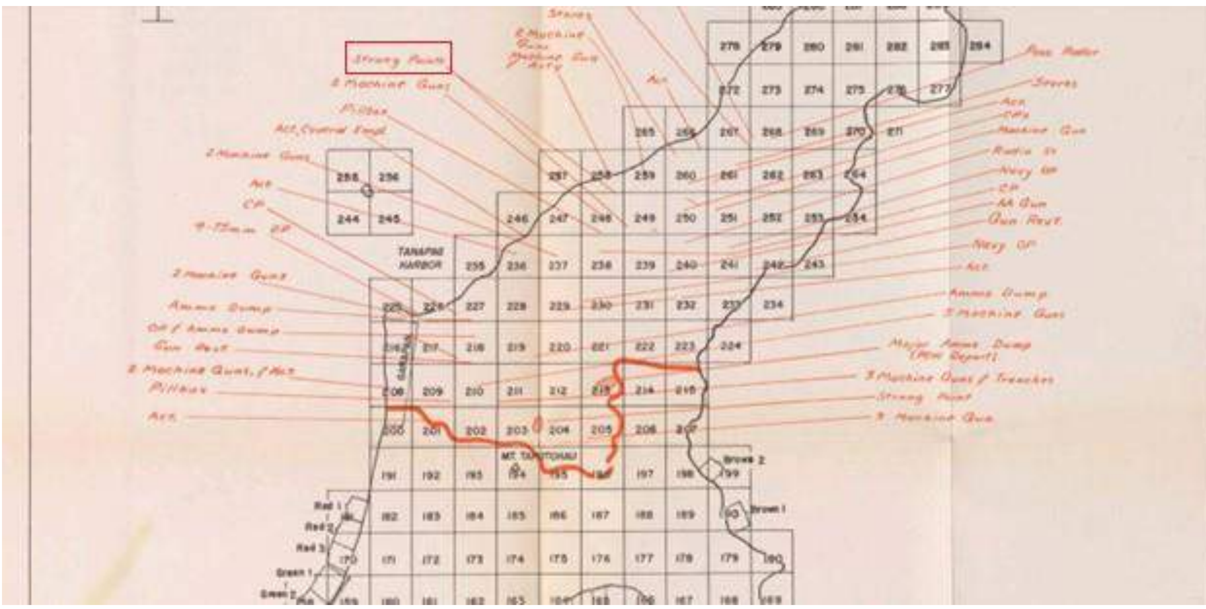


Figure 35. Radar Hill locations labeled as "strong points" in a post-battle intelligence report, June 28, 1944 (Headquarters, Expeditionary Troops, Task Force Fifty-Six 1944).

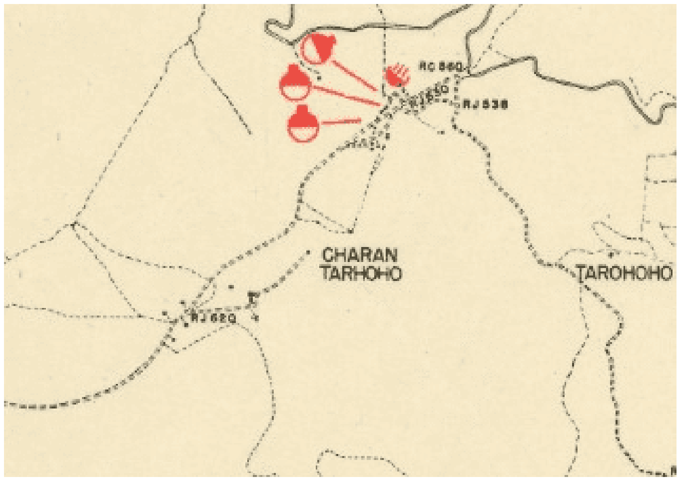


Figure 36. IJN compound structures noted by the author located on Radar Hill from intelligence report with searchlight and three heavy AA guns observed, February 1944 (HQ 27th Inf Division).

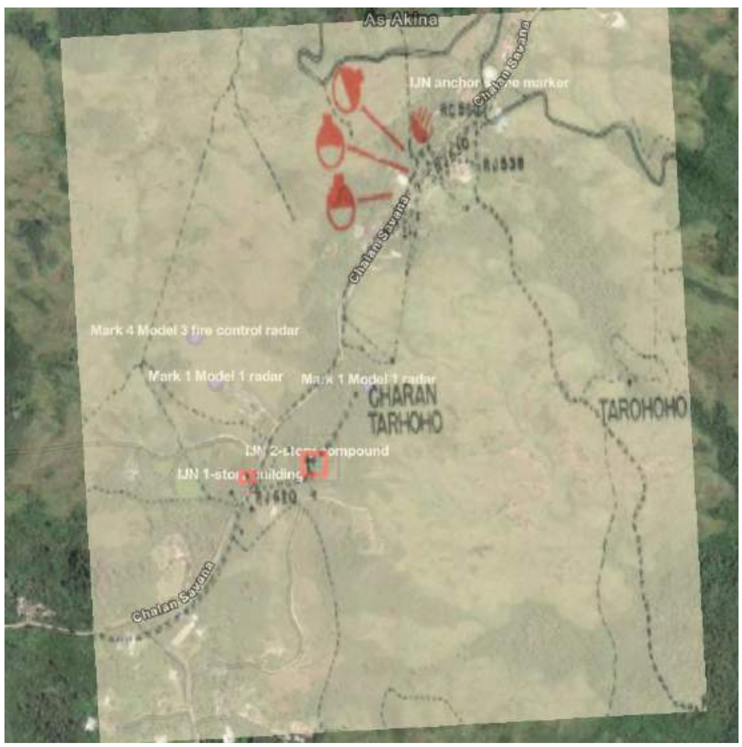


Figure 37. Japanese radar emplacement field in relation to nearby IJN buildings (Image created by author on ArcGIS).

After comprehensive archival research confirming Radar Hill being the site of a radar emplacement location, fieldwork was undertaken. The overlay location was determined to be located on the private property of the closed "Heaven II" Hotel with heavy foliage surrounding it, and no ridgeline could be determined from which the emplacement was located. The site did not appear to have an ideal clear line of sight required for radar employment, and the nearby field was likely employed instead (Figure 38). The Mark 4 Model 3 fire-control radar receiver and transmitter would have a clear line of sight for Tanapag Harbor as well as most of the island to direct AA and shoot down US aircraft. The field was off a ridge, had a clear line of sight to Tanapag Harbor, and had a potential vacuum tube glass casing located on it (Figure 39). The fact that the locations are only within .25 mi. of each other is potentially a minor error in accuracy from reconnaissance reports. The highest elevation location on Radar Hill was also examined, as it would have offered the most optimal clear line of sight for a Japanese search radar. Located there was a corroded mast of iron approximately 30 ft. in length, the height of the Mark 1 Model 1 search radar and potentially belonging to the emplacement (Figure 40).

Figure 38. Mark 4 Model 3 fire-control radar emplacement field overlooking Tanapag Harbor filled with submerged downed US aircraft with local historian and guide Fred Camacho (Photograph taken by author March 2022).

Figure 39. (Left): Potential vacuum tube located in Radar Hill field, 2015. (Right): Approximately 80 vacuum tubes are required for the Mark 1 Model 1 radar receiver and transmitter. (Photographs courtesy of Fred Camacho (left) and Naval Research Laboratory 1943).

Figure 40. Suspected destroyed antenna, potentially Mark 1 Model 1 radar. Corroded metal bar approximately 30 ft. long found at the peak of Radar Hill (Photograph taken by author March 2022).

In US Intelligence maps, an IJN command post was noted on Radar Hill, and this notification was likely accurate given the advanced technical nature of radar and the clear view to Tanapag Harbor below it. The command post was attempted to be located in the surrounding area of the field on public property where the radar was employed on Radar Hill (Figure 41). The Mark 4 Model 3 on Radar Hill would have been employed similarly to the Japanese “Type 2 & 3 Fire Control” systems (Figure 42). The Takao City, Formosa Mark 4 Model 3 fire-control radar emplacement is believed to be of similar orientation to Radar Hill’s Mark 4 Model 3 fire-control radar infrastructure (Figure 43). The captured Mark 4 Model 3 fire-control radar receiver and transmitter were photographed following the battle (Figures 44-47). The entire Wireless Ridge area down to Tanapag Harbor was occupied by the IJN, particularly by the 2,000 men of the 55th Naval Guard Force under Captain Takashima (Hoffman 1950:282) (Figure 40). The dirt road across Radar Hill remains almost identical to how it was in July 1944 and thus assisted in navigating the area (Figure 48). A stone marker was located on this road near the radar emplacements, including the IJN anchor and a chrysanthemum, further confirming the IJN’s leadership over Wireless Ridge (Figure 49). With permission from the private landowners who own most of the property on Radar Hill, local guide Fred Camacho and the author attempted to locate the Japanese command post. Camacho had talked to locals who had seen the compound in 2015 after extensive forest fires on Radar Hill had exposed the structures.

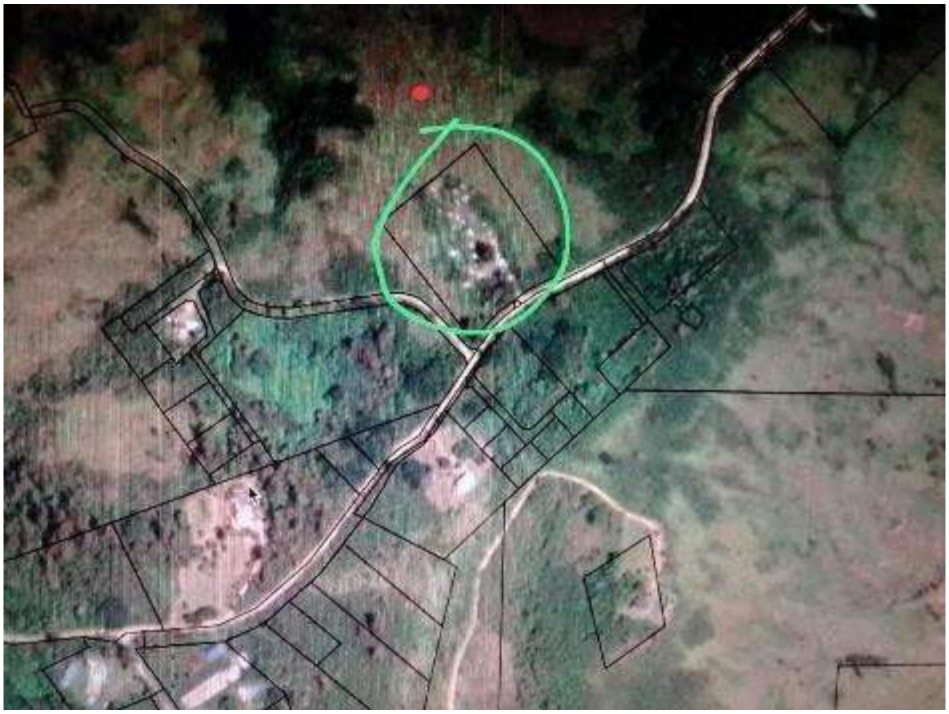


Figure 41. Radar Hill private property. Cemetery adjacent (circled) to Radar Hill field (red dot) (Image courtesy of Fred Camacho).

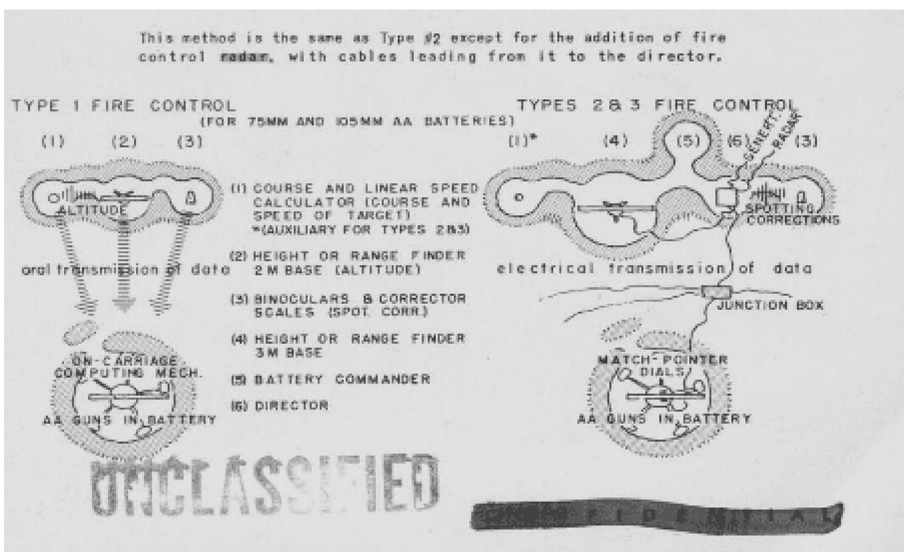


Figure 42. Mark 4 Model 3 or Type 3 fire-control radar and AA battery functional diagram, see "Type 2 & 3 Fire Control" (Office of the Chief of Naval Operations 1945b).

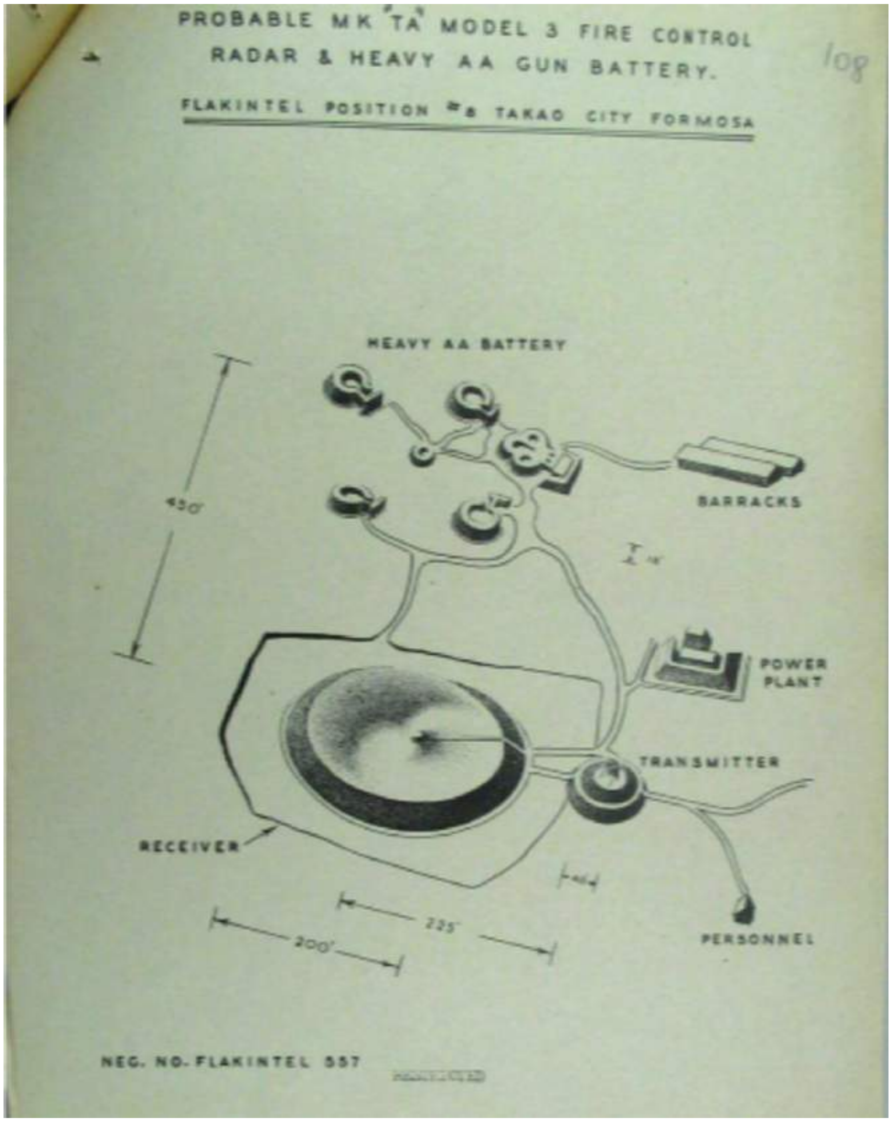


Figure 43. Takao City, Formosa Mark 4 Model 3 fire-control radar emplacement, believed to be of similar orientation to Saipan's Radar Hill Mark 4 Model 3 fire-control radar (RAAF Command Headquarters 1945:96).

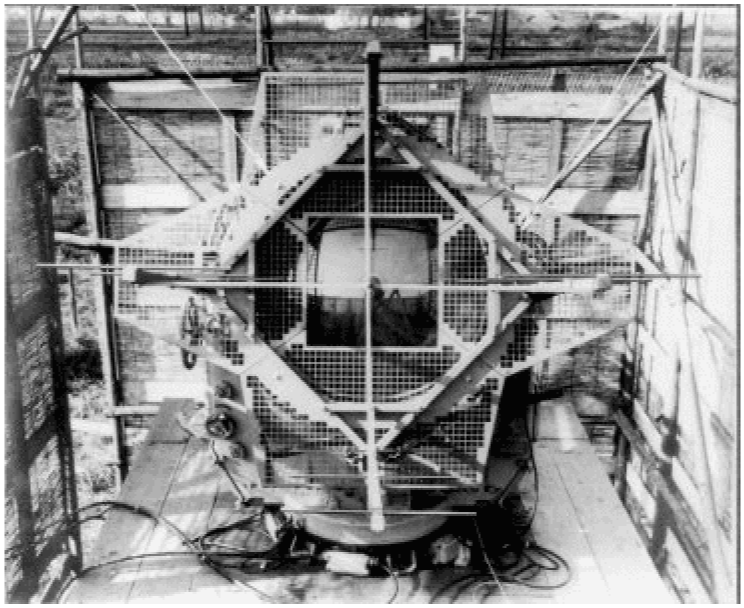


Figure 44. Mark 4 Model 3 fire-control radar receiver captured on Saipan, front, July 1944 (Land Radar of the Japanese Navy 2018).

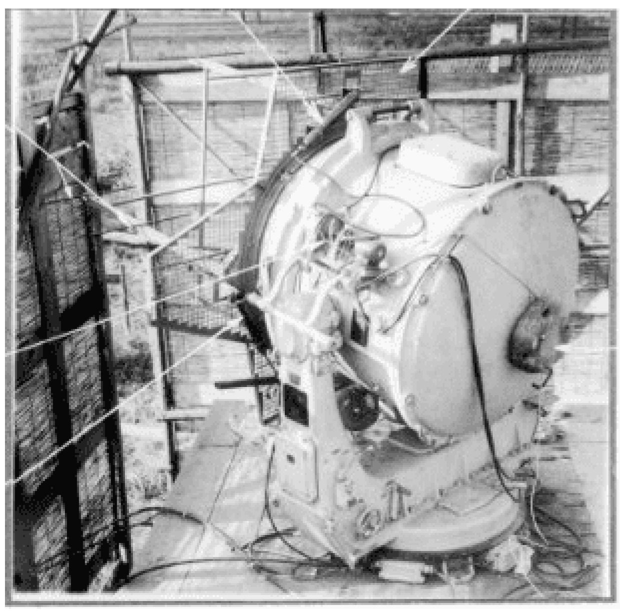


Figure 45. Mark 4 Model 3 fire-control radar receiver captured on Saipan, side, July 1944 (Land Radar of the Japanese Navy 2018).

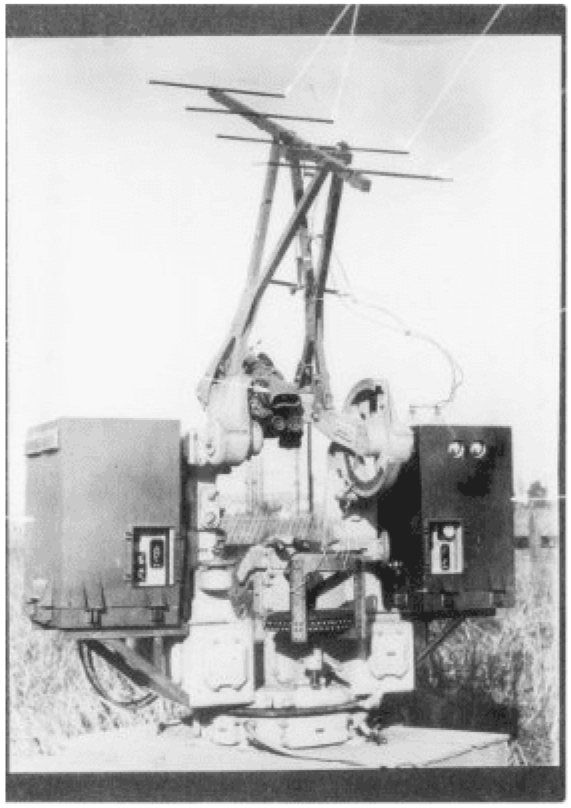


Figure 46. Mark 4 Model 3 fire-control radar transmitter captured on Saipan, July 1944 (Land Radar of the Japanese Navy 2018).

Figure 47. Mark 4 Model 3 fire-control radar transmitter captured on Saipan, scope, July 1944 (Land Radar of the Japanese Navy 2018).

Figure 48. US Marines on Radar Hill's main road, 5 July 1944 (The First Battalion, 24th Marines).

Figure 49. A concrete marker with an Imperial Japanese Navy anchor with a chrysanthemum in the center was found adjacent to the road near the radar emplacement location (Photograph taken by author 3 May 1944, facing east).

The Mark 4 Model 3 fire-control radar was also likely based at Radar Hill as the location was an open field with a clear line of sight to Tanapag Harbor. It would have been employed with the search radar on Radar Hill to consolidate detection capabilities, spare radar equipment such as vacuum tubes, and IJN technical expertise and leadership. The Naftan Peninsula location had no optimal employment sites for fire-control radar, such as an elevated field with a clear line of sight and no nearby active anti-aircraft emplacements. Meanwhile, Radar Hill has post-battle footage of the location that potentially shows the receiving element of the Mark 4 Model 3 radar (Figure 50). Additionally, this reel has a battery of 80 mm. anti-aircraft guns from which the Mark 4 Model 3 fire-control radar could have directed the AA guns automatically (Figure 51). In this same reel, a destroyed Mark 1 Model 1 search radar is shown, further confirming the location to be Radar Hill (Figures 52-53). An additional reel was also located showing a destroyed Mark 1 Model 1 search radar believed to have been on Radar Hill (Figure 54). An intelligence photo was also located that potentially shows the destroyed Mark 1 Model 1 search radar on Radar Hill (Figure 55). Post-battle intelligence photos were also located that show the Radar Hill 80 mm. AA battery, where the location can further be verified.

Figure 50. Potential Japanese Mark 4 Model 3 fire-control radar receiver module on Radar Hill shown on post-battle footage, 22 July 1944 (National Archives and Records Administration 1944b).

Figure 51. Type 3 80 mm. AA gun on Radar Hill shown on post-battle footage, radar antenna shown in the upper right background, 22 July 1944 (National Archives and Records Administration 1944b).

Figure 52. Japanese Mark 1 Model 1 aerial search radar on Radar Hill shown on post-battle footage (National Archives and Records Administration 1944c).

Figure 53. Destroyed Japanese Mark 1 Model 1 aerial search radar on Radar Hill shown on post-battle footage, 22 July 1944 (National Archives and Records Administration 1944b).

Figure 54. Destroyed Mark 1 Model 1 aerial search radar (National Archives and Records Administration 1944a).

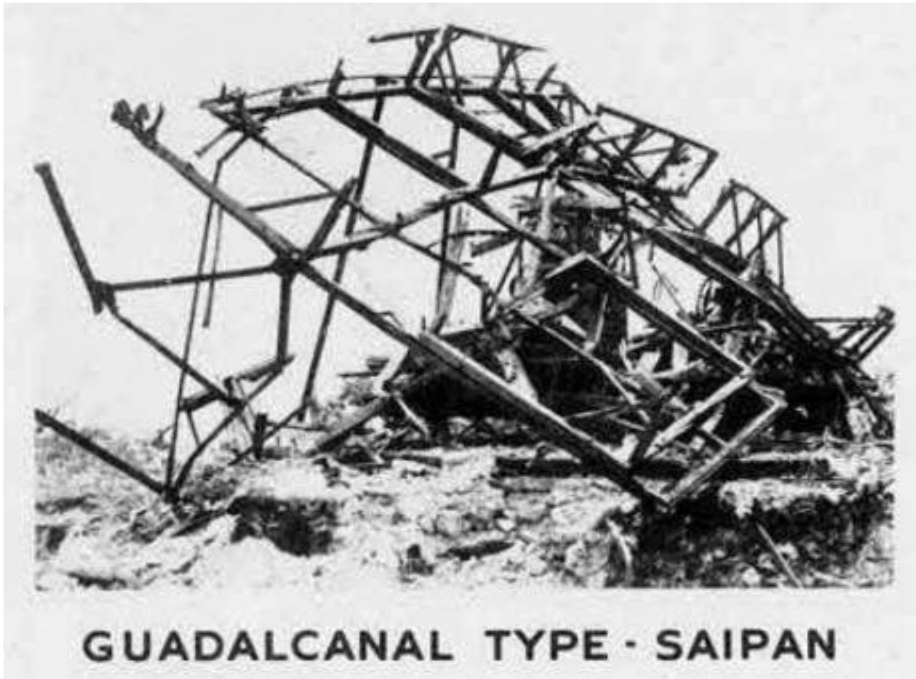


Figure 55. Wrecked Mark 1 Model 1 aerial search radar (Division of Naval Intelligence 1945:28).

A one-story building was located off the main road 650 ft. from the radar emplacement field, with various toppled Shinto shrines at the entrance of the building. The outside base of the building is constructed of tiling and concrete with the roof intact (Figures 56-58). The dimensions are approximately 20 ft. by 40 ft. and 15 ft. in height, and there is a doorway on the northern and eastern sides of the structure, with a water cistern directly outside the eastern doorway. There are four window openings in the south and north of the building and two on the eastern and western faces. Various small arms bullet holes cover the entire structure, likely created by Able Company of 1-24 Marines on 3 July 1944. Various artifacts were located inside the building, including multiple sake bottle shards, ceramic electrical insulators, and a brass artillery casing. The inside of the building is collapsed rubble and a sink from which a pipe from the cistern ran. The structure is highly ornamental and likely a command post of IJN officers.

Figure 57. Interior of "Radar Hill" command headquarters southern building, potentially housed IJN radar operators/ technicians and IJN leadership (Photograph taken by author March 2022).

Figure 56. Eastern entrance of "Radar Hill" command headquarters southern building (Photograph taken by author March 2022).

Figure 58. Corner profile of Radar Hill command headquarters southern building (Photograph taken by author March 2022).

Initially, this building was considered the sole Japanese structure on Radar Hill. Then, the property owner and landscaper informed the team that upon clearing brush and constructing houses in the area, a compound of several buildings was located 500 ft. from the sole one-story building and 800 ft. from the radar emplacement field. The landscaper led the team to an area that appeared to be a sizable command post of the IJN. Outside the buildings were small arms bullet holes and evidence of a significant high explosive opening that appears to have been caused by a 75 mm. gun from a M4 Sherman tank (Figure 59). The structure was two stories high and comprehensive in size (Figure 60). Due to time and logistical considerations, only a brief site surveillance could be conducted. Notably observed was a large two-story structure that appeared to be barracks with multiple iron bed springs. A modern Japanese paper memorial shrine was observed in one of the rooms. The building also had a maintenance room where a painted tool wall could still be observed. The wall showed where specific maintenance tools were located as they were painted in black for proper placement and accountability of the tools (Figure 61). This room likely provided the technical equipment to maintain the nearby Japanese radar emplacements.

Figure 59. Japanese two-story Radar Hill headquarters, likely tank round (75 mm.) impact site (Photograph taken by author March 2022).

Figure 60. Japanese two-story Radar Hill headquarters, 2nd floor walkway (Photograph taken by author March 2022).

Figure 61. Japanese two-story Radar Hill headquarters maintenance room tool wall (Photograph taken by author March 2022).

Notably observed within the two-story building were multiple name and date engravings from American occupation soldiers dating to 1944-1962 (Figure 62). The name and year engravings in the structure ended in 1962 when the US Central Intelligence Agency (CIA) operations ceased on the island. Throughout the 1950s to 1962, the CIA occupied much of Saipan (Jeans 2018:127-128). Primarily, this was to train Chinese Nationalists in guerilla operations to overthrow Maoist China. The CIA headquarters on the island was on the Capitol Hill administrative section and only about one mile away from Radar Hill (Nufer 1978:50). Training operations included espionage, explosives, guerilla tactics, radio communications, escape and evasion, and other intelligence tradecraft based on what was trained at the CIA's "The Farm" training facility during the 1950s in Virginia (Jeans 2018:128). This compound located on Radar Hill was potentially repurposed from its IJN technical facility for radar operation to a technical training "black site" of the CIA (Jeans 2018:127-128). These structures are believed to be the most substantial standing buildings that still exist on Saipan from the battle, and considerations should be made for a survey and their preservation. A comprehensive survey was planned for these buildings in May 2023, with several months of planning and agreement to the survey, but the property owners later denied permission to survey the site.

Figure 62. US Army occupation soldiers' engravings inside IJN two-story headquarters (Photograph taken by author March 2022).

5.2. US Aircraft vs. Japanese Radar and AA ArcGIS Model

The fields of fire or principal sky watch locations of Japanese anti-aircraft emplacements on Saipan were closely connected to the radar emplacements on the island (Figure 63). The search radar emplacements were able to alert the Japanese anti-aircraft emplacements, some of which were radar-controlled as well. It also alerted defenders that a US attack on the island was imminent. Given the state and range of Saipan’s Japanese radar emplacements in June 1944, the detection of approaching US aircraft was up to approximately 300 km. or even more if atmospheric conditions were ideal (Figure 64). The defenders had well over an hour to ready the island’s anti-aircraft emplacements to the appropriate azimuth and elevation of the approaching US aircraft (Wilkinson 1946a:19). The anti-aircraft defenses on the island were comprehensive, linked through a communications system and a 360-degree overlapping fields of fire defense. This effective system was uncovered through a captured Japanese document following the battle, where concentrations of fire were clearly established.

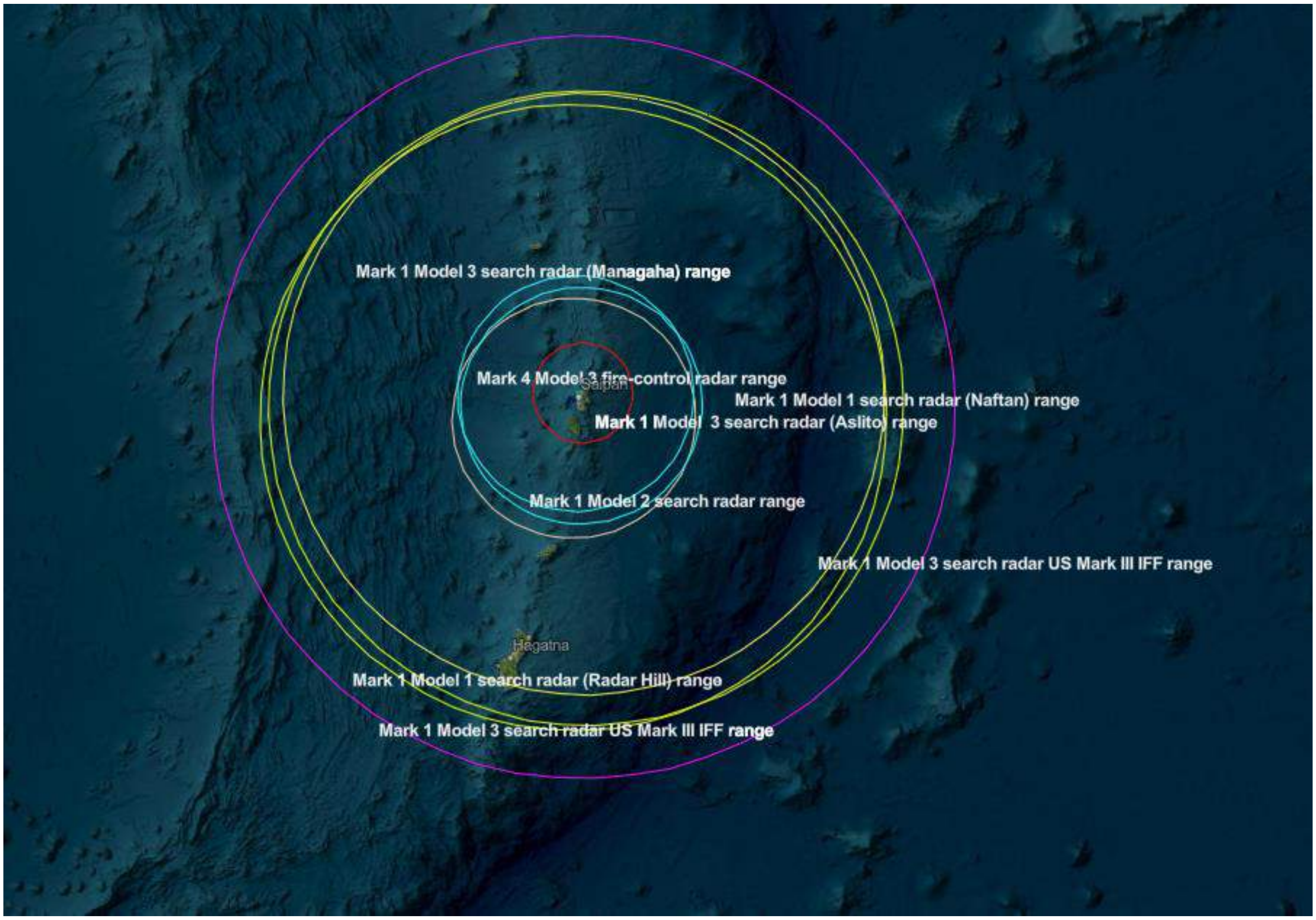


Figure 63. Saipan Japanese radar emplacement range (Image created by author in ArcGIS).

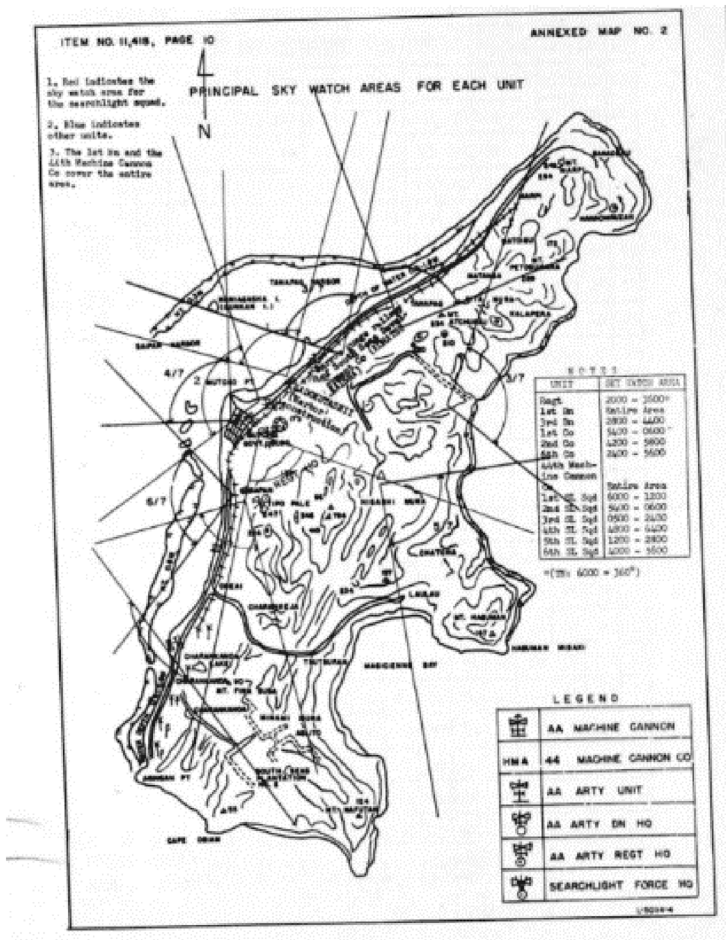


Figure 64. Captured Japanese document on the principal sky watch areas or fields of fire for each AA unit at Saipan (U.S. Pacific Fleet, and Pacific Ocean Areas (U.S. Pacific Fleet, and Pacific Ocean Areas (CINCPAC-CINCPOA) 1945a).

Through the established fields of fire of the Japanese AA units on the island, a georectified version of the captured Japanese map was merged with current imagery of the island through ArcGIS (Figure 65). The fields of fire of the Japanese AA units on Saipan were re-established on the created overlay on ArcGIS as triangular basic polygons. The transparency of the triangular fields of fire, represented in yellow color, was then adjusted to 20% for high values and 80% for low values to show the overlap in the fields of fire. The areas of overlap are identified as the highest level of Japanese defense via yellow shading. The heaviest concentration of overlap of the fields of fire was determined to be located adjacent to Mañagaha Island and approximately 1.0 mi. northeast of the island. The known and suspected submerged crash site locations of US aircraft are all inside or adjacent to the highest concentration of fire (Figure 66). The suspected crash site of a submerged SBD-5-Dauntless is located inside the highest concentration of fire.

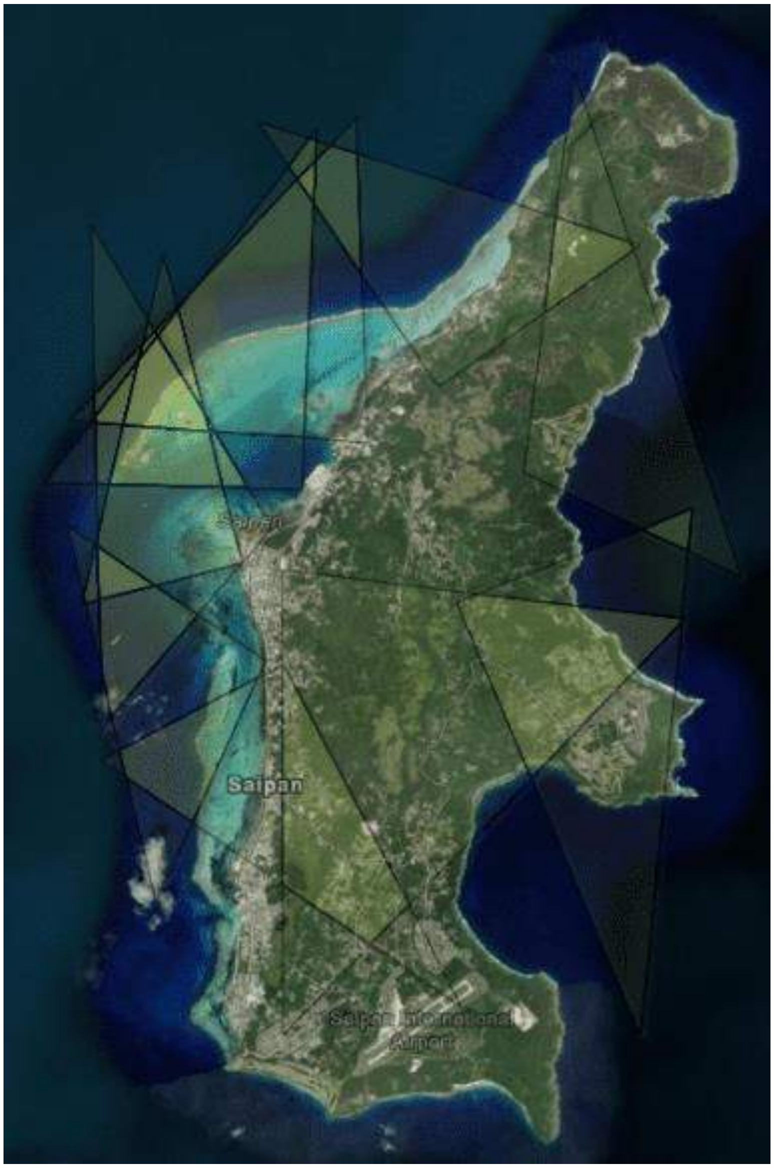


Figure 65. Saipan Japanese AA unit fields of fire fields ArcGIS model from captured Japanese AA principal sky watch areas document, highest concentration of fire shown in Tanapag Harbor (Image created by the author on ArcGIS).

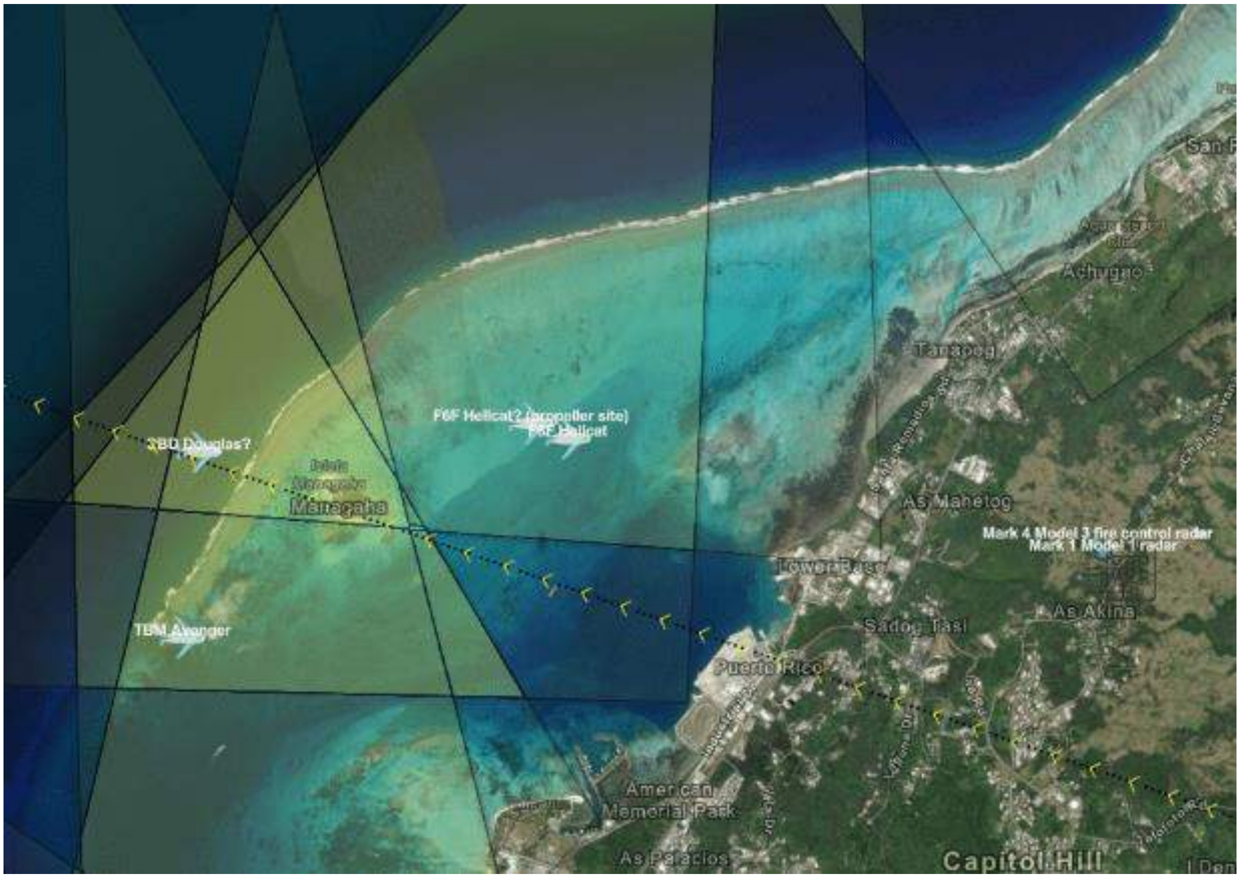


Figure 66. All located US aircraft are located adjacent to the highest concentration of Japanese AA. Shown east is the suspected Japanese Mark 4 Model 3 fire-control radar that enabled the destruction of those aircraft (Image created by the author on ArcGIS).

Notably, the US Identification Friend or Foe (IFF) or military transponder that used radar to identify friendly from enemy aircraft operated on a similar frequency as the Mark 1 Model 3 radar that was employed in Dandan Village off Aslito and potentially the variant used on Mañagaha Island. This meant that US aircraft employing Mark III IFF would shoot radar pulses to ping these Japanese emplacements and let them know their location at up to 300 km., or even further if atmospheric propagation conditions were ideal. This maximum range is near where TF 58 was reported to have been compromised, per intercepted Japanese radio communications on USS *Lexington* as "a Japanese language expert aboard *Lexington* intercepted radio traffic indicating the task force had been spotted, Mitscher went ahead and launched 208 Hellcat fighters and eight torpedo bombers from about 225 mi. off Saipan for the hour-long flight to the target” (Hallas 2019:67). TF 58 was forced to launch their aerial attack early on 11 June 1944 at 1300 at 13.7° latitude 148.2° longitude 305 km. from Saipan (Figures 67-68).

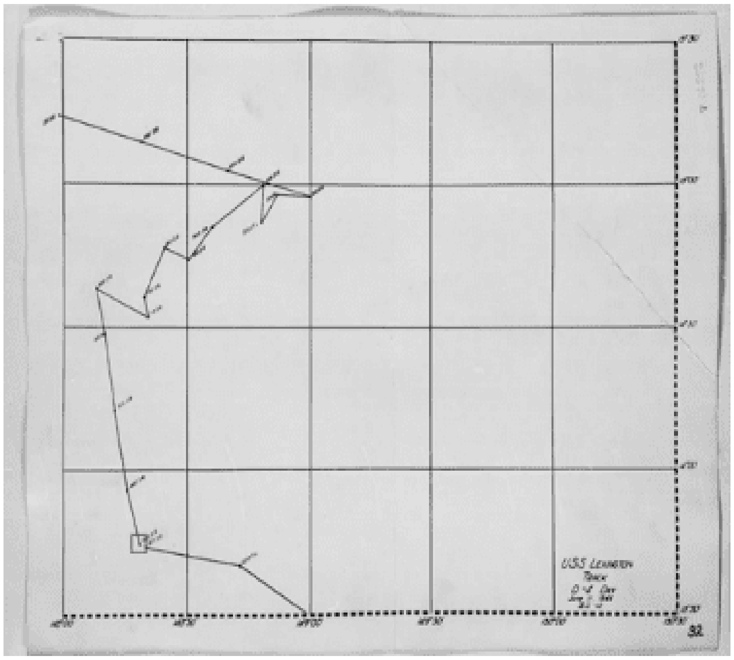


Figure 67. Launch coordinates of aircraft carrier USS *Lexington* with fleet on 11 June 1944 at 1300 after being compromised, noted with red rectangle (USS *Lexington* 1944b).

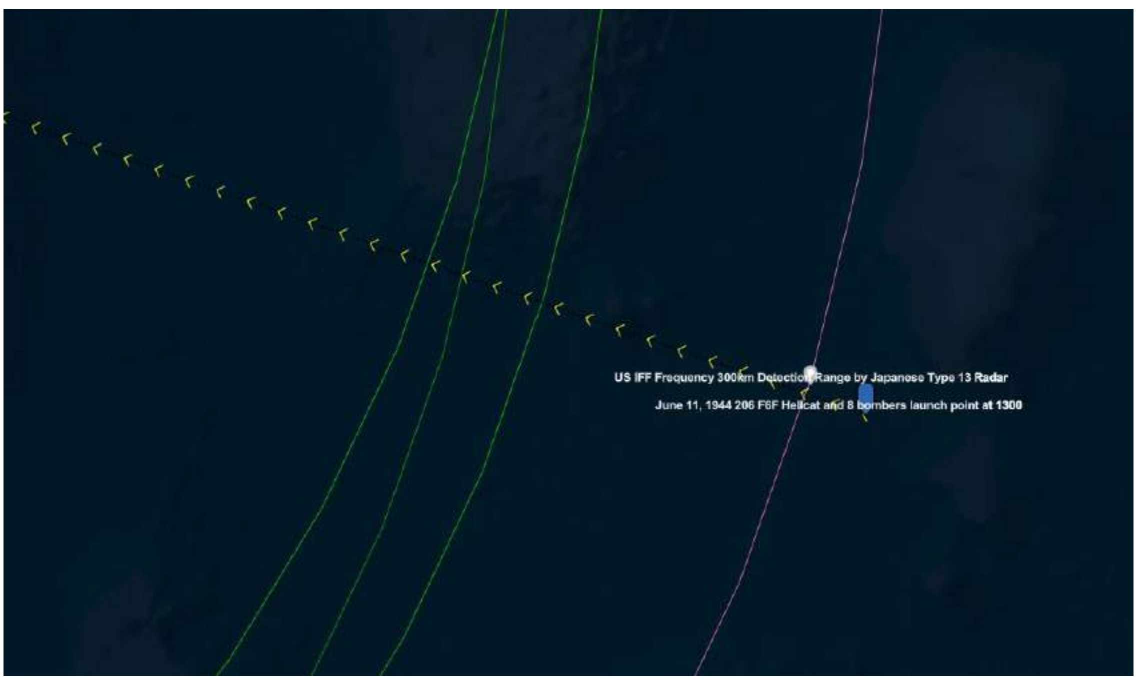


Figure 68. 11 June 1944 aircraft carrier approximate launch point at 13.7° latitude 148.2° longitude 305 km. from Saipan compared to Japanese Mark 1 Model 3 search radar that detected US Mark III IFF systems up to 300 km. (Image created by author on ArcGIS).

The submerged TBM Avenger is located approximately 0.5 mi. south of the highest concentration of Japanese AA fire (Figures 69-70). A suspected crash site location of a US aircraft propeller, believed to be from an F6F-3 Hellcat, is located approximately 0.6 mi. east of the highest concentration of fire. The submerged F6F-3 Hellcat that has been the subject of DPAA MIA investigations from 2019-2023 is additionally located only 0.8 mi. from the highest concentration of AA fire (Figures 71-72). Nearly all these aircraft are believed to be combat losses from the "strong and accurate" Japanese anti-aircraft fire, where the heaviest combat losses over Mañagaha Island were during the initial US attack on 11 June 1944, where 13 US aircraft were lost. Throughout air operations directly over Saipan, only one US aircraft is suspected to have suffered an air-to-air combat loss.

Figure 69. Archeological remains of TBM Avenger with landing gear up, located in Tanapag Harbor downed by Japanese AA in June 1944, July 2018 (McKinnon 2019).

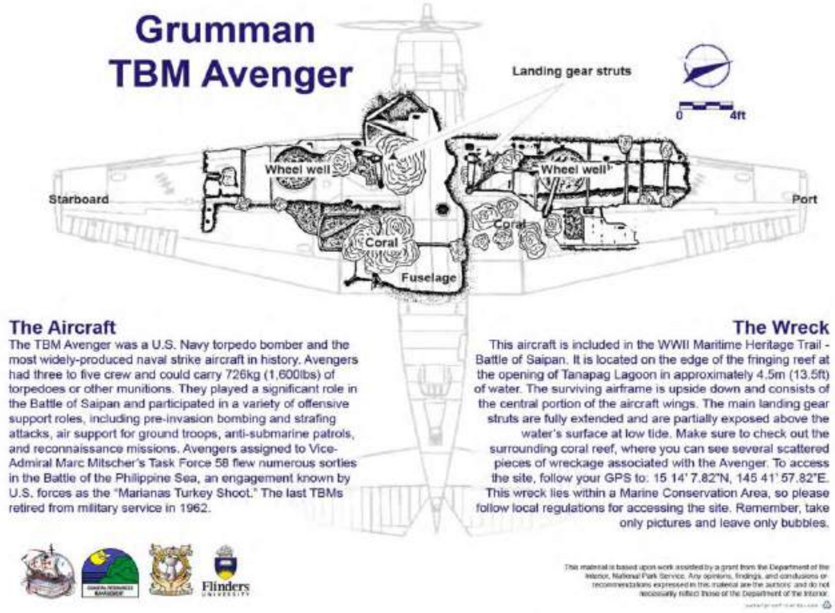


Figure 70. Diagram of archeological remains of TBM Avenger located in Tanapag Harbor downed by Japanese AA in June 1944, July 2018 (McKinnon 2019).

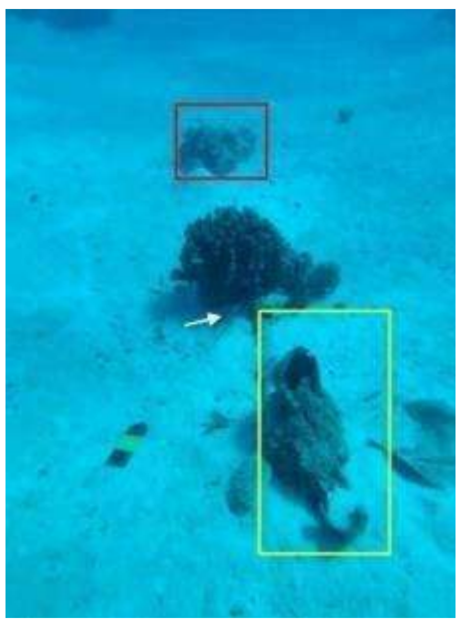


Figure 71. F6F-3 Hellcat downed by Japanese AA in Tanapag Harbor. Engine (indicated by red square), landing strut and tire (indicated by yellow square), and .50-caliber gun (indicated by white arrow); 30 cm. scale, view looking north (McKinnon 2019).

Figure 72. Radar Hill Mark 4 Model 3 emplacement field from Tanapag Harbor nearby submerged F6F Hellcat site, circled by author (Photograph taken from Tanapag Harbor by author in May 2023).

Given that multiple submerged US aircraft were all identified within 1 mi. of the highest concentration of Japanese AA fire, the overlap of defenses is likely predictive of additional downed US aircraft that were lost through combat. Particularly, this will likely be represented through the combat losses of US aircraft on 11 June 1944, as almost all were through surface-to-air Japanese AA fire. There were a total of 81 US aerial losses from 11 June 1944 to 9 July 1944, when Radar Hill was captured, and the AA defense of the island had effectively collapsed at this point. War Diaries and Aircraft Action Reports indicate 16 of the US aircraft losses during this period were from Japanese AA fire, and 30-40 in total with the likelihood of being downed by Japanese AA fire over Saipan. The 12 US aircraft shot down on 11 June 1944 was the highest loss rate to Japanese land-based AA fire until that point in the war. Combat losses after 11 June 1944 directly over Saipan would have been through Japanese AA fire and likely where the highest concentration of fire was located. 16 June 1944 appears to be the pivot date when most Japanese AA emplacements were destroyed by US aircraft, and their loss circumstances after this date decreased drastically, not to mention anti-aircraft fire. It is likely there are multiple additional MIA downed submerged US aircraft located in or around the highest concentration of Japanese AA fire. Particularly, this is likely to be the case 1.0 mi. northeast of Mañagaha Island on and beyond the reef that has never been archaeologically surveyed where Japanese AA artillery flak fragmentation and even US aircraft wreckage might be located. Some wreckage may still be concreted to the coral reef. Additionally, the area northeast beyond the reef with the highest concentration of Japanese AA fire needs to be examined, as the area directly southeast of it had potential target hits from a magnetometer survey searching for an SBD-5 Douglas aircraft. This aircraft or additional MIA US aircraft could be located in this area just beyond the reef, and the area is in great need of a sonar and magnetometer survey (Figure 73). The depths of the coral reef are 1-4 ft. at the crest, and the proposed area of survey beyond the reef goes down to approximately 89 ft. of water depth.

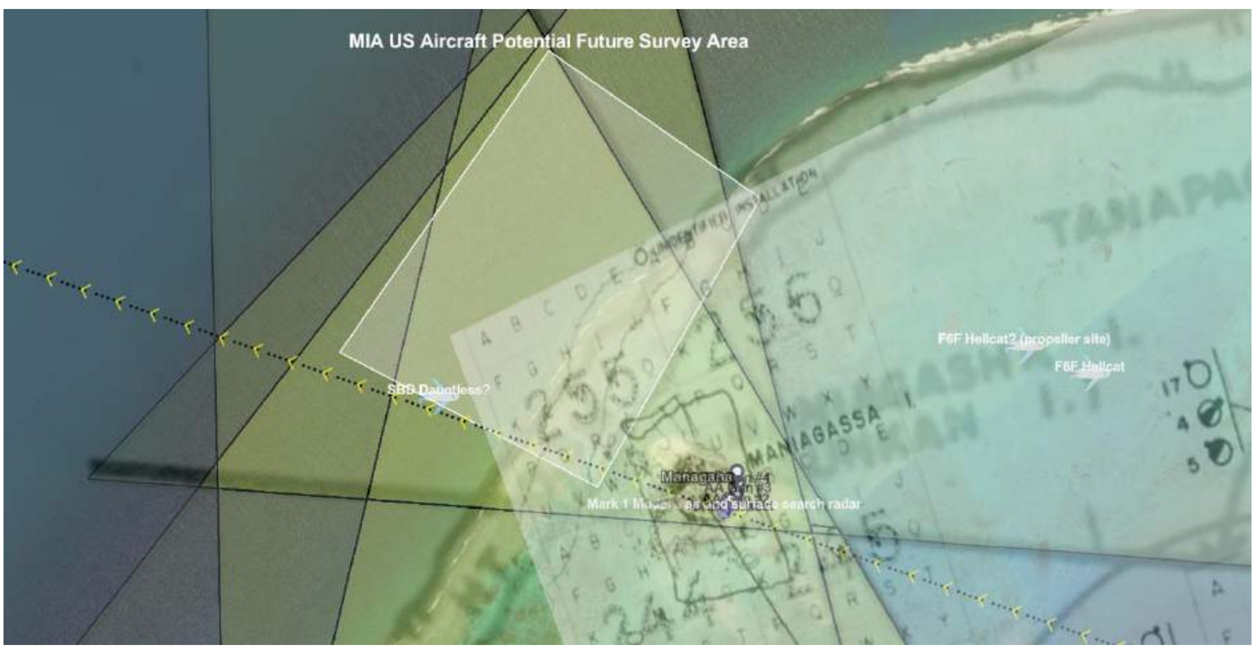


Figure 73. Survey potential for MIA US aircraft in highest Japanese AA overlap and adjacent areas on and beyond coral reef (Image created by author on ArcGIS).

Notably, the highest concentration of Japanese AA fire is located only 3.0 mi. away from Radar Hill and the field where the Mark 4 Model 3 fire-control radar was believed to have been employed. This is well within its range capabilities through a clear line of sight and easily enabled adjacent Japanese AA guns on Radar Hill to automatically track and destroy US aircraft attacking the nearby Tanapag Harbor (Figure 72). The azimuth and elevation of attacking US aircraft could additionally be relayed from this emplacement to Japanese AA guns throughout the island to level and fuse their guns appropriately. Through the lack of US intelligence of the Japanese possessing fire-control capabilities, there is a strong likelihood that the Mark 4 Model 3 fire-control radar is directly related to multiple US aircraft losses in and around Tanapag Harbor.

The detection capabilities of the radar emplacements were also able to be effectively established on this model. The plotted radar emplacements, identified through archival and archaeological evidence, were plotted on Mount Lasso on Tinian, Tinian's northern airfield, Dandan Village, Mañagaha Island, and the Radar Hill emplacements as all these sites had substantial evidence of their existence. Colored circular lines, per type of radar, were used to establish the maximum effective range of each emplacement and their ability to detect formations of US aircraft. The comprehensive detection capabilities of the Japanese defense of Saipan can be effectively established where the Japanese had multiple layers of warning. Approximately three early warning search radar emplacements on Saipan and Tinian were able to detect the US aerial attack preceding the invasion on 11 June 1944. The US aircraft could be detected at a maximum range of around 250 km. or even more depending on atmospheric conditions, giving the Japanese defenders and their anti-aircraft emplacements nearly 1.5 hrs. to prepare for the attack. Given that layered warning, the Japanese could not fully scramble their aircraft at Aslito Airfield prior to the attack on 11 June 1944. To rearm and refuel a small aircraft takes approximately 20 min. Degassing almost all the planes in the airfield fully explains why only approximately 40 Japanese aircraft were in the air when the US aircraft arrived. Additionally, the shared command and control of the IJN and IJA command of the southern sector of the island surely did not assist in scrambling the aircraft.

5.3. Naftan Peninsula Survey

The Naftan Peninsula Mark 1 Model 1 radar emplacement was observed in May 1944 by US aerial surveillance, and the site was plotted on intelligence maps (Figure 74). *Naftan* in Chamorro means grave or burial place, and the location has great historical and cultural significance as a site of ancient habitation. An attempted survey was conducted in the March 2022 fieldwork season, but the radar emplacement failed to be located due to the thesis still being in its initial phases of archival research and time constraints. A photo of the site that had been taken in 2012 and posted on a blog by a user who had previously located the site was used as a reference photo to relocate and further pinpoint the location. On 3 May 2023 and 5 May 2023, with the expert assistance of local guide Fred Camacho, the site was located within two hours.

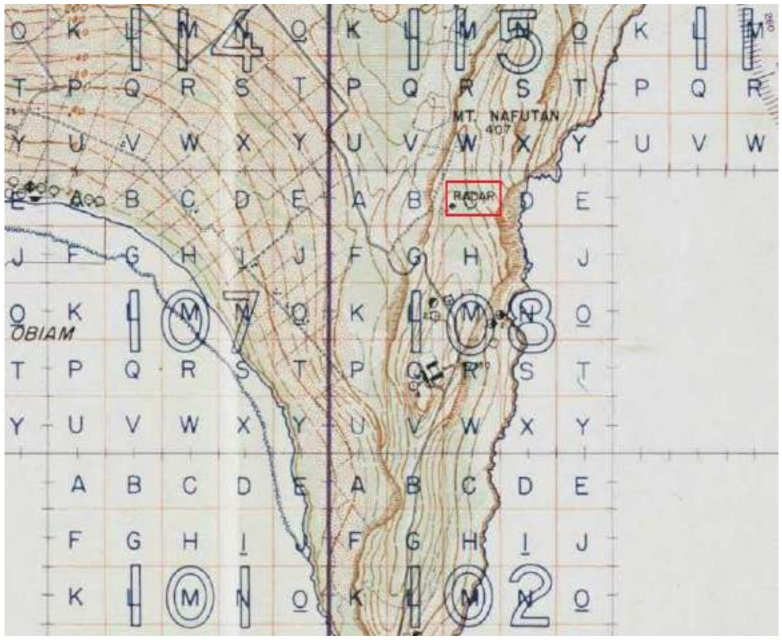


Figure 74. May 1944 Saipan US Intelligence map with Japanese radar emplacement plotted on Naftan Peninsula (HQ 27th Inf Division 1944).

The structure is located on an elevated terrain with a clear line of sight of the eastern and western approach of the peninsula. The dense foliage currently obscures this view, but a clear line of sight optimal for radar detection was established through a machete clearing exercise. The plan of the building was established through GPS, with building corners, doorways, and notable features marked with GPS, with their significance being noted (Figure 75). The structure was approximately 20 ft. by 40 ft. in dimension, with the radar tower on the eastern face of the building. Later research determined the site had been previously surveyed by the Historic Preservation Office in 1996, but its role had never been identified (Figure 76).

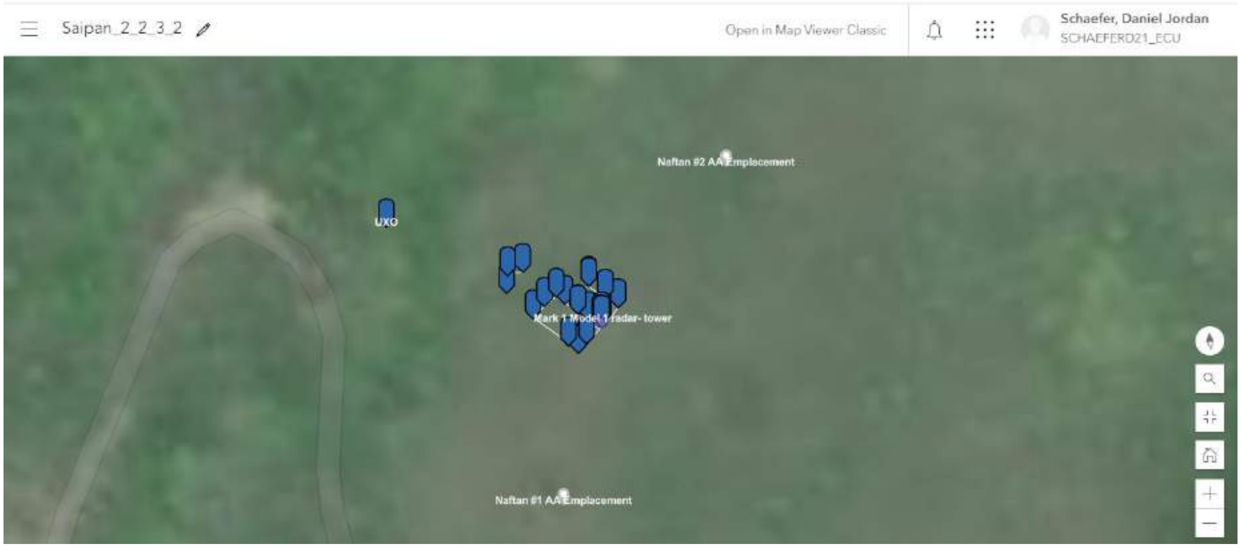


Figure 75. Naftan Peninsula Japanese radar emplacement with key features and anti-aircraft emplacements plotted (Image created by author in ArcGIS).

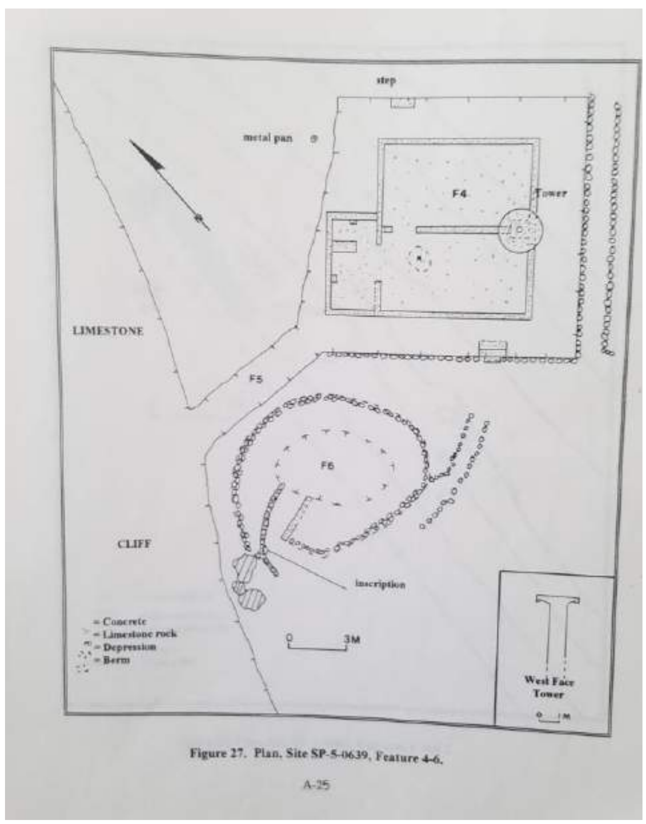


Figure 76. HPO 1996 survey of Naftan Peninsula Japanese radar emplacement Plan, Site SP5-0639, Feature 4-6 (Image courtesy of Saipan's Historic Preservation Office).

The construction materials consisted of concrete, plaster, and rounded iron rebar, which were all standard materials in Japanese construction. Plastering is used outside the building for a waterproofing effect for protecting the sensitive electronic equipment used to power the emplacement and operate the radar. The building itself was constructed in a depression where it was easily concealed with foliage, with only the radar tower being exposed for detection capabilities. The building was in the same location as extensive US aerial and naval bombardment during the initial days of the invasion. Approximately 500 Japanese soldiers had fled to the tip of the Naftan Peninsula following the invasion and loss of Aslito Field. They attempted a breakout on 26 June 1944, which led to almost a complete loss and effectively ended Japanese hostilities on the Naftan Peninsula (Hallas 2019:321). The structure appears to have suffered a direct impact from heavy bombardment from US forces. The concrete roof is wholly collapsed, with many large sections scattered around the building. The building was readily exposed to attack, with the foliage depleted through bombardment fires.

Outside of the building, facing west towards the primary Naftan Peninsula road above the depression, is what appears to be a semi-circular barricade covered in plaster believed to have been used as a defensive fortification. Outside of the structure, located 90 ft. from the compound, a 1,000 lb. AN-M65A1 unexploded bomb is located deeply impacted in the soil. These bomb variants were commonly used by the US SBD-5 Dauntless dive bomber, launched through a precision-based attack from the centerline of the aircraft's fuselage. The unexploded ordinance was noted, recorded, and marked for potential disposal.

The radar emplacement tower was approximately 8 ft. tall with a circular base diameter of 5 ft. (Figures 77-78). Located in the center of the base of a mounting hole, sheathed in lead plating, for the radar antenna that appeared to go down the entire height of the tower (Figure 79). The construction materials consisted of concrete, plaster, and rounded iron rebar. Due to the power required for transmitting radar beams, it is believed that this radar was the transmitting antenna. The location of the receiving element of the antenna could not be confidently determined due to the dense foliage but was believed to have been filmed when soldiers of the 27th Infantry Division captured Naftan Peninsula (Figures 80-81).

Figure 77. Naftan Peninsula Japanese radar tower, May 2023 (Photograph taken by author 3 May 2023 facing west).

Figure 78. Naftan Peninsula Japanese radar tower with Mark 1 Model 1 radar sketch, May 2023 (Sketch created and photograph taken by author 3 May 2023, facing west).

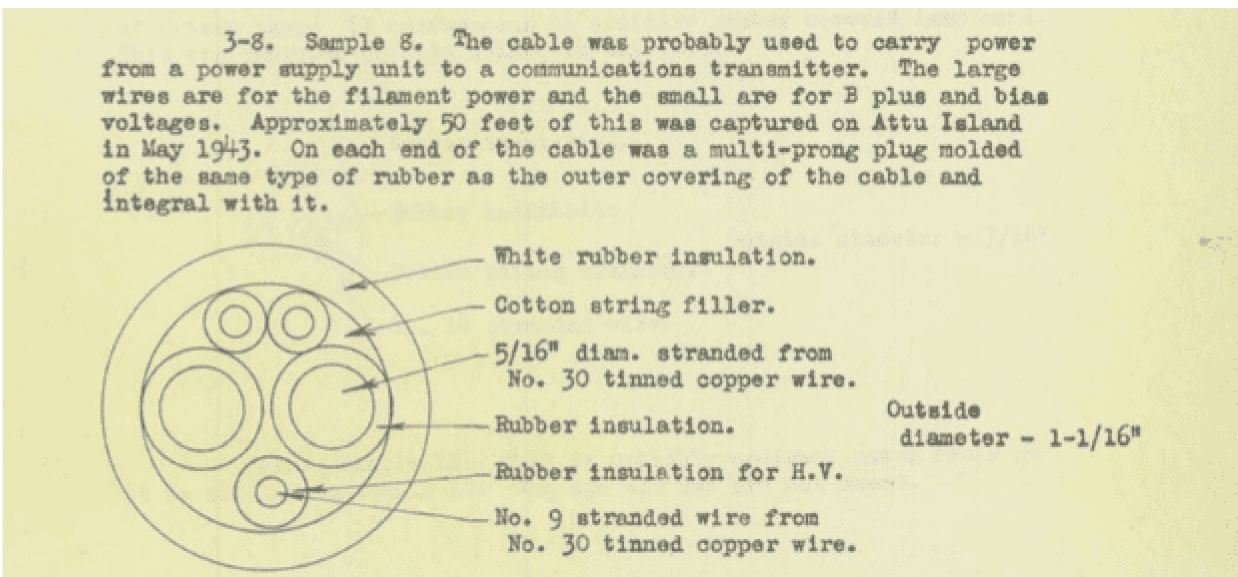
Figure 79. Naftan Peninsula Japanese radar tower antenna mount from top, May 2023 (Photograph taken by author 3 May 2023, from top of tower).

Figure 80. Footage of destroyed Model 1 Mark 1 aerial search radar, Saipan 1944, Naftan Peninsula (National Archives and Records Administration 1944d).

Figure 81. Empty 127 mm. AA gun emplacement in Naftan Peninsula radar footage (National Archives and Records Administration 1944d).

Notably, an approximately six-inch cable terminal was identified off the eastern wall of the structure (Figure 82). Most cables in the building appear to have been cut and scrapped long ago due to their copper content. Thus, they were only observed where they led underground. Notably identified was a white rubber-insulated cable approximately one inch in thickness. It was identified through TM-E 30-480: *Handbook on Japanese Military Forces* as "probably used to carry power from a power supply unit to a communications transmitter. The large wires are for the filament power, and the small are for B plus and bias voltages" (War Department 1944:319-320) (Figure 83). This cable is likely for the power supply of the Naftan Peninsula radar itself, as radio communications power supplies of the era operated on very similar technology.

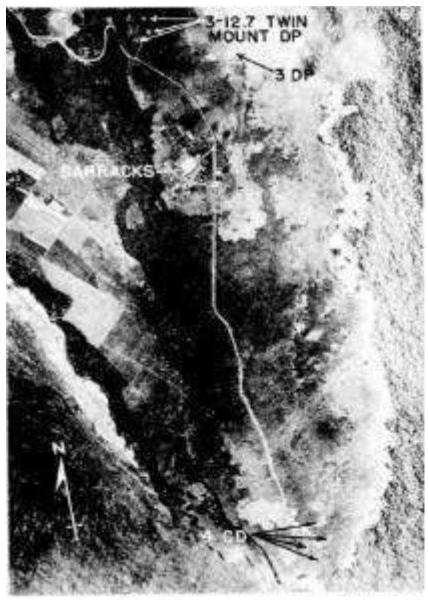
Figure 82. Naftan Peninsula radar emplacement building underground cable port with wires (Photograph taken by author 3 May 2023, no scale, facing east).



3-8. Sample 8. The cable was probably used to carry power from a power supply unit to a communications transmitter. The large wires are for the filament power and the small are for B plus and bias voltages. Approximately 50 feet of this was captured on Attu Island in May 1943. On each end of the cable was a multi-prong plug molded of the same type of rubber as the outer covering of the cable and integral with it.

Figure 83. White rubber insulation cable from power supply unit to a communications transmitter (Bonham 1944:2).

The cables appear to have been linked to two anti-aircraft emplacements located near the emplacement. A third emplacement was reported in May 1944 reconnaissance maps but could not be located during the survey (Figure 84). Both were within 90 ft. of the radar emplacement and in a precise defensive posture of the emplacement. Identical cable terminals were located in both of the anti-aircraft emplacements. No longer present, a 12.7 cm. dual-purpose gun could be used in a dual naval artillery and anti-aircraft role (Figure 81). The guns were located post-battle in a Garapan train depot still packed in cosmoline non-corrosive grease (Hoffman 1950:13). These anti-aircraft emplacements were set up to protect the emplacement as well as relay the radar data to the gun emplacements via underground cable, giving the guns an enhanced fire-control capability.



NAFUTAN POINT (18 April)

Figure 84. Three 127 mm. AA guns were observed near the Naftan Peninsula radar emplacement (Joint Intelligence Center Pacific Ocean Area (JICPOA) 1944d).

The radar the Japanese employed at Naftan Peninsula was the Mark 1 Model 1 search radar. This was confirmed through captured Japanese documents describing the operation protocols of the Naftan Peninsula site and Radar Hill emplacements on 24 August 1943 and archival footage of the 27th Infantry Division upon its capture (Figure 80). The standardized rotation speed for the Naftan Peninsula and Radar Hill search antennas was one 360-degree revolution every two minutes. There were three strict conditions of readiness for the radar emplacements and condition one where peak readiness was employed, 0200-0800, 1000-1600, 1800-2400; the emplacement was observed and was turned on during the 24-hour day (U.S.

Pacific Fleet, and Pacific Ocean Areas (CINCPAC-CINCPOA) 1943). The emplacement would have been the one that had eventually detected the approaching aerial attack at approximately 250 km. on 11 June 1944 that launched at 1300. If the emplacement was still in operation on 15 June 1944, at 0700, it was observing and reporting on the amphibious assault of the island. A telegraph room was adjacent to every radar emplacement, directly wired into higher command and a nearby lookout post to confirm detected blips on the radar visually. The necessary IJN radar operator staff was one radar room officer, 4-5 monitor personnel, and a scope reader. The strict warning procedures followed permitted rapid detection and immediate transmission of reports.

5.4. Dandan Village Survey

The Dandan Village Mark 1 Model 3 search radar was attempted to be located on 5 May 2023. The 1945 *Photographic Interpretation Handbook, United States Forces: Japanese Electronics*, identified the site as "located on a ridge about 1,300 yds. north of the east end of the Aslito runway (Figure 85 and Figure 86). The building that housed the radar appeared to be constructed of wood and roofed with corrugated tin paneling. The iron antenna mast of the Mark 1 Model 3 radar is approximately 30 ft. tall, enabling 360-degree detection capabilities, and was camouflaged with foliage to hinder enemy detection. The Japanese operators and analysis deliberately destroyed the radar, and equipment could not be conducted on the systems. Given its nearby location, the site was likely coordinated with Aslito Airfield, reporting incoming aircraft (Figure 87). Primarily, this was approaching Japanese aircraft attempting to land. Most notably, the Mark 1 Model 3 radar operated on a similar frequency to the US Mark III IFF and the module that detected the Task Force 58 invasion fleet on 11 June 1944 at 1300, 300 km. away from Saipan (USS *Lexington* 1944b).

Figure 85. Type Mark 1 Model 3 Japanese search radar, Saipan 1944, 1300 yds. north of the eastern end of Aslito Airfield 1945 (Division of Naval Intelligence 1945).

CONFIDENTIAL

RADAR INSTALLATIONS

ON SAIPAN

This evidently home-made radar installation was found on SAIPAN. It was located on a ridge about 1300 yards north of the east end of ASLITO runway.

A study of the photographs indicates that this antennae was probably meant to be used with a Mark 13 (temporarily designated Type 3 Mark 1 Model 3) portable radar. It is apparently also adapted for use with a Type 3 Air Mark 6 Model 4 modified for use on land. Both of these radars operate on or near 150 megacycles. The Mark 13 is higher powered and able to detect aircraft at a much greater range. (See "Weekly Intelligence", Vol. 1, No. 8).

Further assessment of this equipment is not possible. When discovered, the radar had apparently been destroyed.

Lower right: Rotating mechanism for antennae. The cord attached to the cross piece is evidently a "stop" so that the antennae pole will not be turned through a greater arc than allowed by the lead wires connected to the antennae outside the building. Bearings are obtained from the indicator and dummy compass rose on the floor at the base of the pole.

//

PAGE 33

Figure 86. US Intelligence report on Mark 1 Model 3 Japanese search radar, Saipan 1944, 1300 yds. north of the eastern end of Aslito Airfield (US Strategic Bombing Survey 1944).

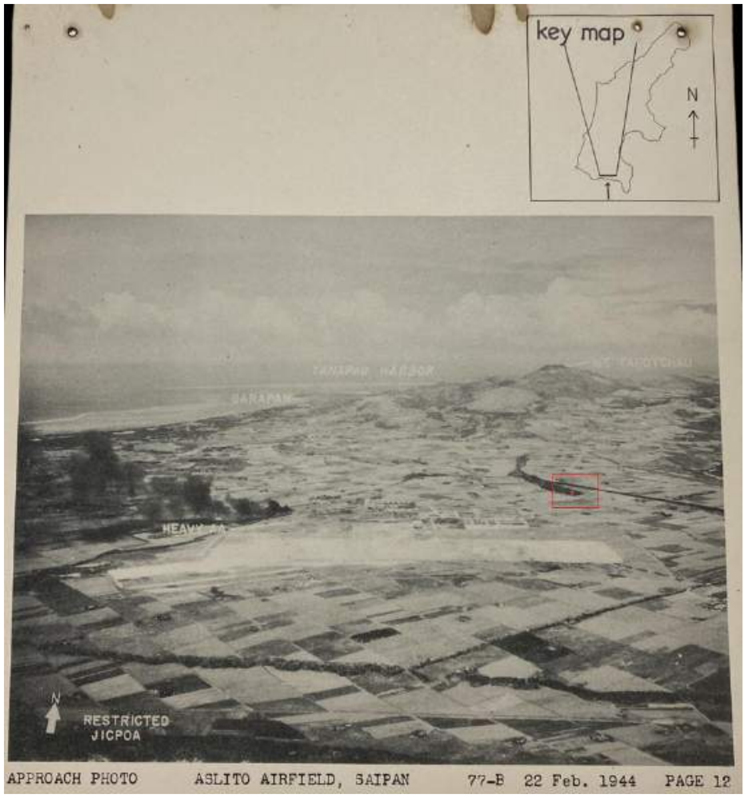


Figure 87. Approximate location of Mark 1 Model 3 radar emplacement from US aerial reconnaissance photo, 22 February 1944 (Joint Intelligence Center Pacific Ocean Area (JICPOA) 1944b:12).

A survey was attempted, yet it was difficult as the location had faced much urban development in the decades following the battle (Figure 88). With the assistance of Fred Camacho, meetings were established with local property owners to see if they or their families were aware of the location's history or any potential artifacts/structures observed on their property. One property on the Dandan Village ridge at the end of Mestisa Ave, with a clear line of sight to the eastern airfield, matches the archival data, but unfortunately, no solid identification could be established due to the heavy urban development.

Figure 88. Suspected present location of Mark 1 Model 3 Japanese search radar, Saipan 1944, 1,300 yds. north of the eastern end of Aslito (now Isley) Airfield (Image created by author on ArcGIS).

5.5. MAÑAGAHA ISLAND SURVEY

Mañagaha Island is a small island that lies off the western coast of Saipan, located within Tanapag Harbor, just inside the coral reef. Mañagaha means “pearl” in Chamorro due to the island’s shape (Fred Camacho May 2023, pers. comm.). The island consisted of a substantial defensive buildup in the years before the battle by the empire of Japan with two coastal artillery Type 45 15 cm. cannons, Type 96 light AA guns, and heavier unidentified anti-aircraft gun emplacements, per a US Navy intelligence report from 15 May 1944 (Figure 89). The island faced heavy US aerial bombardment in the initial days of the invasion and was the location of the last major combat operation of battle on 13 July 1944, where an obstinate Japanese resistance was eliminated through an amphibious assault (Hoffman 1950:246).

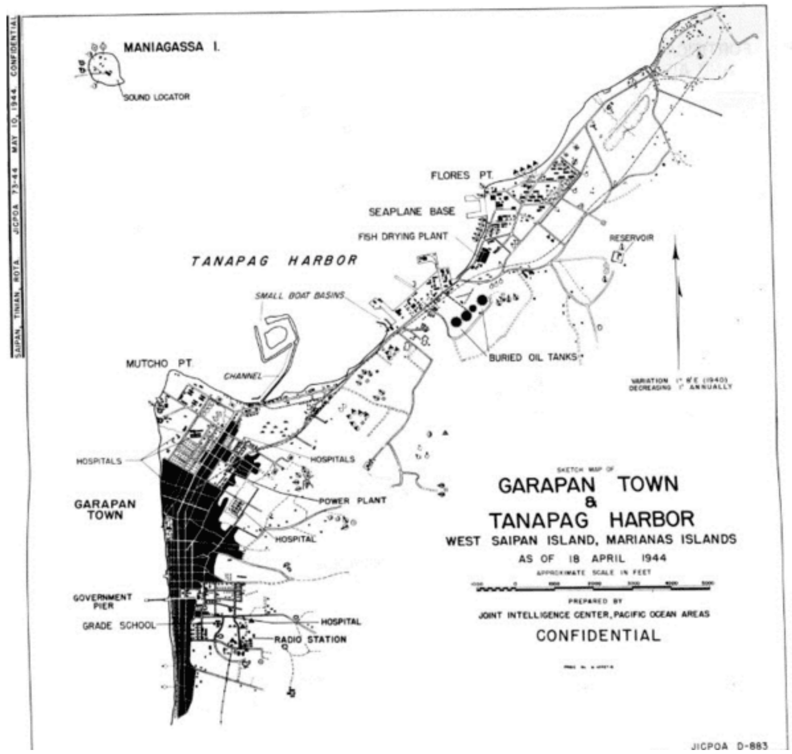


Figure 89. Intelligence report of Garapan Town and Tanapag Harbor, 15 May 1944 (Joint Intelligence Center Pacific Ocean Area (JICPOA) 1944d).

Additionally identified in the intelligence report was a sound locator on the eastern approach of the island (Figure 90). A sound location was a listening device for US aircraft that functioned as a precursor of radar, where the Japanese called their radar emplacements “locators” (Wilkinson 1946a:1). By 1943, these inaccurate systems were severely antiquated, and virtually all had been replaced by radar. This “sound locator” was potentially confused with radar as the Japanese identified both systems as “locators.” US Intelligence likely relied on dated information where the site had previously been a sound locator and was now replaced by a radar emplacement.

Figure 90. Japanese sound locator, predecessor of radar, reported located on eastern Mañagaha in intelligence report of Garapan Town and Tanapag Harbor (Joint Intelligence Center Pacific Ocean Area (JICPOA) 1944d).

The primary evidence that Mañagaha Island was utilized as a Japanese radar emplacement was through the reconnaissance missions conducted by two submarines of Patrol Area 14 (Lotz 2018). These patrols conducted around Saipan were primarily for submerged reconnaissance via periscope to determine the defensive capabilities of the island. The first US submarine, *Flying Fish***,** reconnoitered approximately three miles beyond the reef off Mañagaha Island on 2 February 1943 (Lotz 2018:94). Its focus was on Tanapag Harbor, where only a small Japanese freighter was observed anchored as well as a small warship leaving the harbor. Prominent markers on the island's peaks were also identified as potential observation posts, radar, or communications structures (Lotz 2018:102-103).

The submarine *Whale* then conducted a further submerged survey on 10 March 1943 (Figure 91). Eight vessels were observed at anchor, with considerable aircraft and vessels patrolling around the island. Seaplanes were seen launching from the harbor as a sign *Whale* was detected on radar. Multiple air and surface search radar emplacements were observed, and photographs were taken around the island. Air search radar emplacements were observed on the mountaintops of the island, which were likely the ones on Radar Hill, and the dummy radar emplacement located on Mount Petosukura, northeast of the island. A surface search radar was additionally observed on Mañagaha Island, which is believed to be the Mark 1 Model 3 search radar. The mobile radar was ideal for detecting maritime vessels in a potential invasion and submarines, such as *Whale*, which attempted to sneak into the harbor for surveillance. The radar emplacement was observed rotating 360 degrees every 15 seconds through period interference on *Whale's* own SD radar receiver (Lotz 2018:103). A Japanese torpedo boat and aircraft were employed unsuccessfully to locate *Whale*, likely having been alerted by the radar emplacements. This torpedo boat could be the submerged submarine chaser on the Maritime Heritage Trail in Tanapag Harbor (Lotz 2018:104). Additionally, further reconnaissance was conducted off Tanapag Harbor and Saipan from 17 April 1944 to 22 April 1944, where at the surface, it received interference on its radar receiver and was detected by Japanese radar, likely by the Mañagaha Island radar emplacement (Lotz 2018:248).

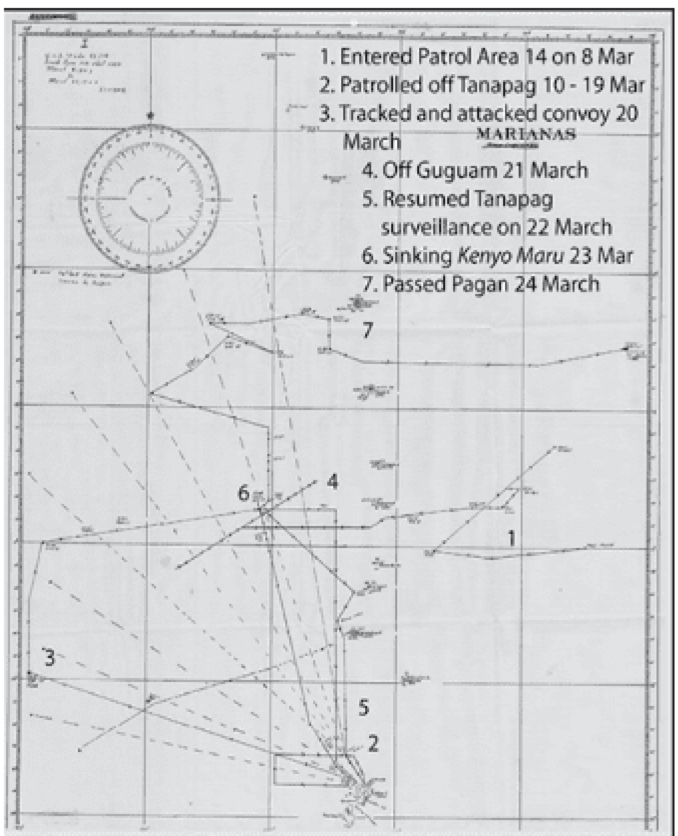


Figure 91. *Whale* 1943 war patrol in Patrol Area 14 in the Marianas Islands (Patrol Area 14: US Navy World War II Submarine Patrols to the Mariana Islands).

The island was surveyed on 11 May 2023, where a terrestrial and underwater survey of the site was conducted. The primary focus was initially on the western approach of the island towards the reef as that was where the US submarines *Flying Fish* and *Whale* observed the radar on Mañagaha Island. These guns were attempted to be located as they could be potentially utilized to defend an adjacent radar emplacement. No archeological evidence could be located via snorkel or on land. A focus was then placed on the eastern approach of the island, where a sound locator, the predecessor of radar, was reportedly observed. Located on the eastern face of the island are the archeological remains of a battery of four Type 96 25 mm. anti-aircraft guns (Figure 92). The guns are semi-submerged in the water as the island's eastern half has heavily eroded (Figure 93). Additionally located through snorkel is a collapsed iron mast approximately 30 ft. in height if erected, similar to the antenna mast height for the Mark 1 Model 3 search radar, such as the one documented in Dandan Village (Figure 94). In a defensive posture, the Type 96 AA guns were recorded semi-circularly around where the mast was located, potentially protecting the site and using its data to add fire-control capabilities to the guns.

Figure 92. Four Type 96 AA guns and a suspected antenna mast are submerged in the eroded eastern half of Mañagaha Island (Image created by author on ArcGIS).

Figure 93. Submerged Type 96 AA located in the eroded eastern half of Mañagaha Island, May 2023 (Photograph taken by fieldwork team, 11 May 2023).

Figure 94. Submerged suspected antenna mast located in the eroded eastern half of Mañagaha Island, May 2023 (Photograph taken by fieldwork team, 11 May 2023).

5.6. PACBAR III "Dummy" Site

This site was determined to be a Japanese "dummy" radar emplacement through archival research. The geographic location was so optimal that it was utilized as a US radar emplacement from 1989 to the early 1990s to detect Soviet missiles and satellites, known as Pacific Barrier Radar III. Mt. Petosukura was identified as a dummy radar emplacement through a 1990 "Environmental Impact Analysis Process Saipan (PACBAR) Radar Mitigation Status Report." The location was initially determined through the War Diary of Able Company of 1-24 Marine Battalion (Figure 95). On 6 July 1944, three days after capturing Radar Hill, the unit uncovered a dummy gun position, dummy Japanese soldiers created from canvas stuffed with foliage, and a dummy Japanese radar emplacement (Engineer, Expeditionary Troops (Task Force 56) 1944) (Figure 96). No actual resistance was encountered at this location. The dummy radar emplacement was meant to mimic the Mark 1 Model 1 search radar.

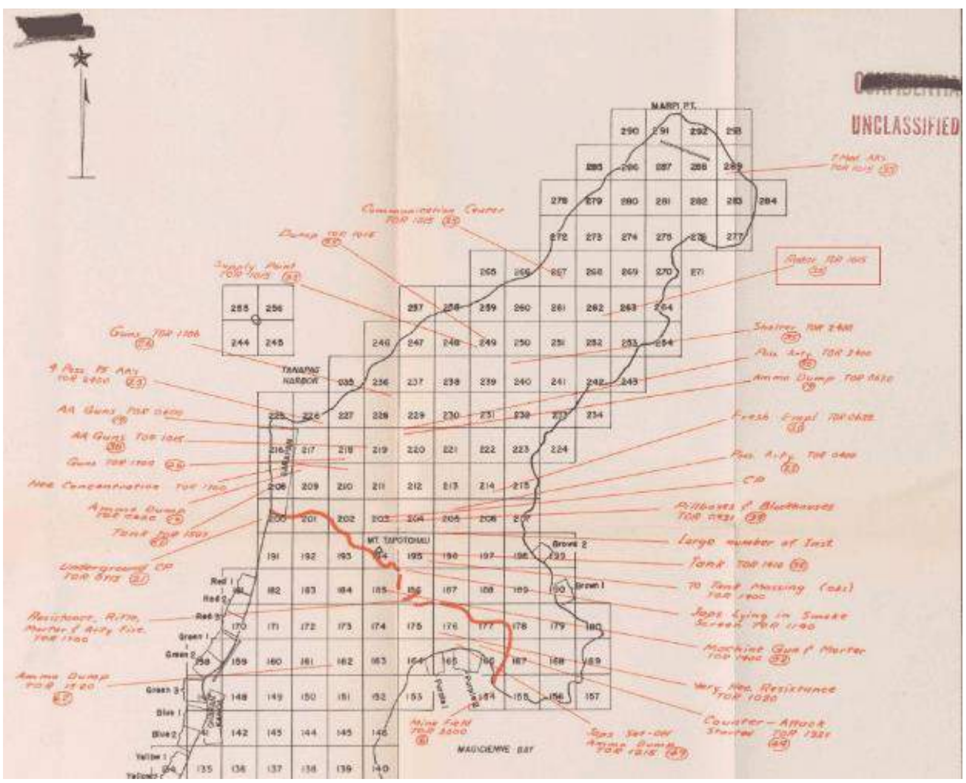


Figure 95. 1-24 Marines line of departure where they reported the "dummy" radar emplacement (Headquarters, Expeditionary Troops, Task Force Fifty-Six 1944).

DUMMY RADAR

The dummy radar screen shown at right is made of ordinary chicken wire. Note the small building behind the screen which was probably expected to represent a radar housing shack. This installation was located on a high treeless mountain between MARPI POINT and MT. TOPATCHAI, SAIPAN.

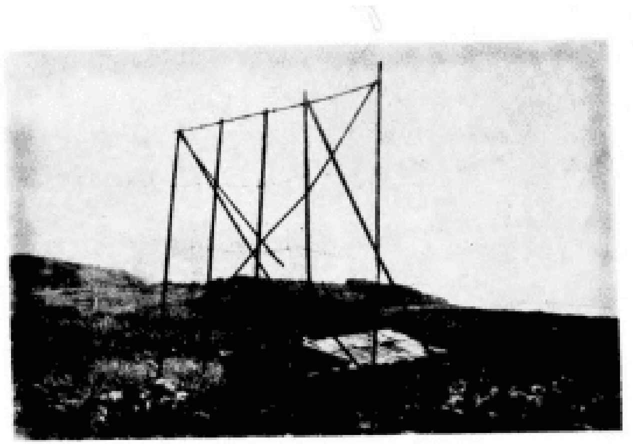


Figure 96. Japanese "Dummy" radar emplacement, modeled after Mark 1 Model 1 search radar, located on Mt. Petosukura, located near the present PACBAR III radar installation (Engineer, Expeditionary Troops (Task Force 56) 1944:84).

Fred Camacho conducted the PACBAR "Dummy" radar site survey on Mt. Petosukura in May 2022. The site was marked as a potential radar emplacement through a March 1944 intelligence map. Initially, Camacho attempted to locate any existing Japanese structures at the site and determine if a radar antenna could be located there or if it was a dummy location. The site was optimal as it offers a clear line of sight through the entire north of the island. Camacho was able to locate a concrete foundation that held two wooden masts at the eastern cliff of Mt. Petosukura (Figure 97). No other structures could be identified from the location given on the intelligence map.

Figure 97. Present "dummy" Japanese radar emplacement location near PACBAR radar compound, concrete "antenna" base located by Fred Camacho (Image created by author on ArcGIS).

The construction and dimensions appear identical to the actual radar, with a 26 ft. x 18 ft. rectangular screen of five horizontal half-wave dipole antennas created from wooden poles and wire (Division of Naval Intelligence 1945:5). Behind the radar screen was a 10 ft. x 10 ft. wooden control shack that would give the radar 360-degree coverage with an operator behind the "dummy" and actual radar emplacement (Figure 96). The site offers an optimal line of sight for detection north of the island. Likely, this site was employed where US aircraft would confuse the site for the actual nearby emplacement on Radar Hill, where false reconnaissance intelligence would be reported, as well as a wasted effort and expenditure of ordnance.

5.7. Tinian Radar Emplacements Surveys

The survey of the Tinian Japanese radar emplacements could not be conducted due to time and logistical constraints (Figure 98). The Tinian radar emplacements hold significant value because the emplacement functioned as a secondary radar during the battle for Saipan if the radar emplacements on Saipan were damaged or destroyed and could no longer provide intelligence on the location of US aircraft. This information could then be relayed to Guam via radio communications, which could be directly wired to mainland Japan through a secure and unbroken communications submarine telegraph cable (U.S. Pacific Fleet, and Pacific Ocean Areas (CINCPAC-CINCPOA) 1945f)**.**

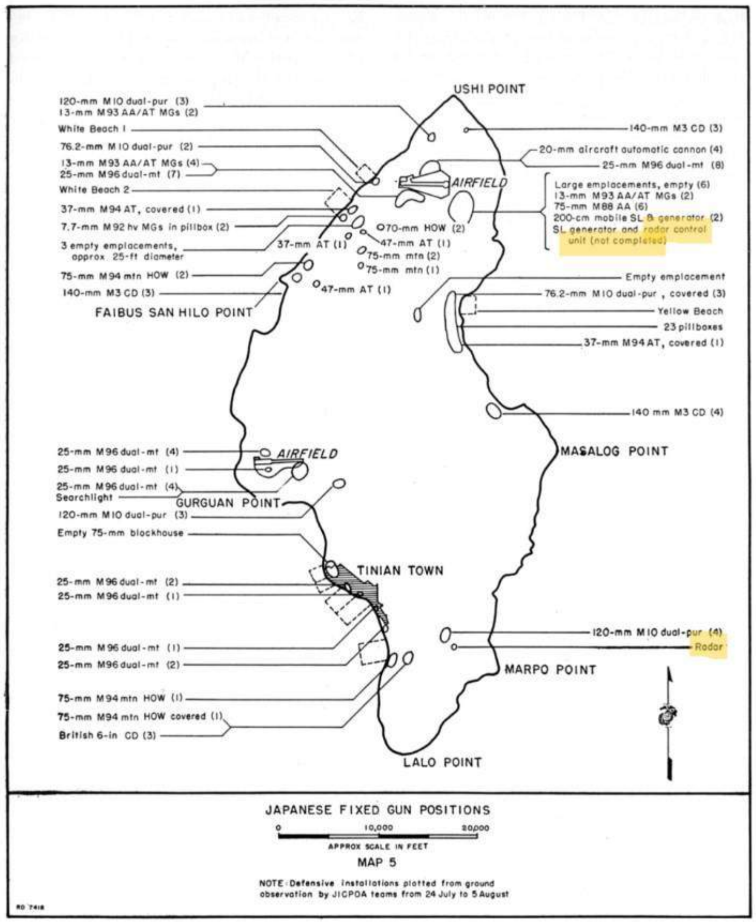


Figure 98. Two Japanese radar emplacements reported on Tinian in US intelligence report (Hoffman 1951:15).

Two Japanese radar emplacements were identified on Tinian through archival sources (Figure 99). The Japanese Mark 1 Model 2 or "Mobile Mattress" radar was reported in intelligence reports to have been located on the northern airfield (Figure 100). It likely functioned similarly to the Mark 1 Model 3 mobile search radar in Dandan Village off Aslito

Airfield. The emplacement was likely utilized as a primary function for locating approaching aircraft to the airfield and was photographed destroyed in a post-battle intelligence report. The intelligence report noted an additional radar emplacement in the south of the island as being the primary fixed radar installation of the island. The post-battle intelligence report refers to the radar emplacement as an "Attu" type as the Japanese Mark 1 Model 1 Modification 1 radar was first discovered by US Intelligence in Attu in the Aleutian Islands in 1942 (Division of Naval Intelligence 1945:10).

Figure 99. Tinian Japanese radar emplacements (Image created by author in ArcGIS).

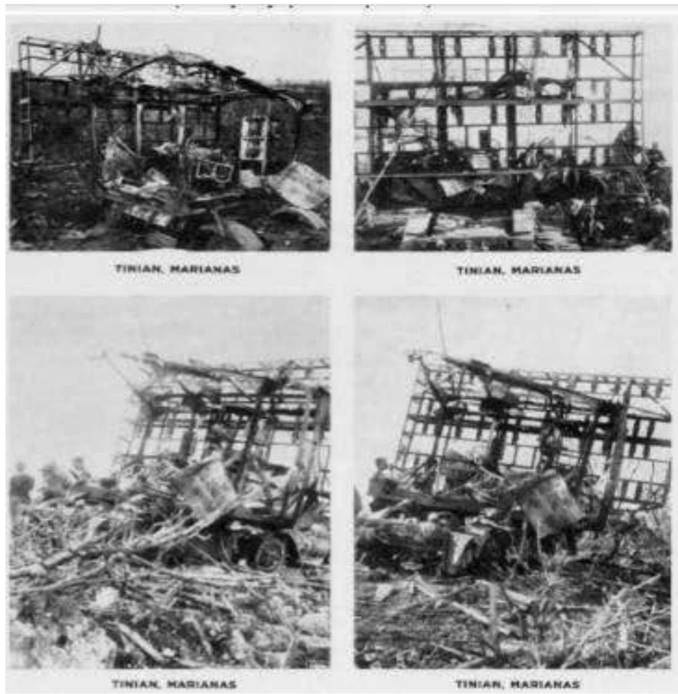


Figure 100. Destroyed Mark 1 Model 2 aerial search radar located off the northern Tinian airfield from post-battle intelligence report (Division of Naval Intelligence 1945:14).

The location of the Mark 1 Model 1 Modification 1 radar was mentioned as having been located on Mount Lasso in northern Tinian by a travel blogger, Howard Cole, in February 2008. The blogger additionally acquired a picture of this installation from the writings of Andres Nazario, a US Navy Seabee who occupied Tinian (Figure 101). At the same time, the intelligence report marks the location as an “empty emplacement” (Hoffman 1951:15). Potentially, this is faulty intelligence, or the radar was not installed when it was observed, which gives Tinian three suspected Japanese radar emplacements (Figure 99).

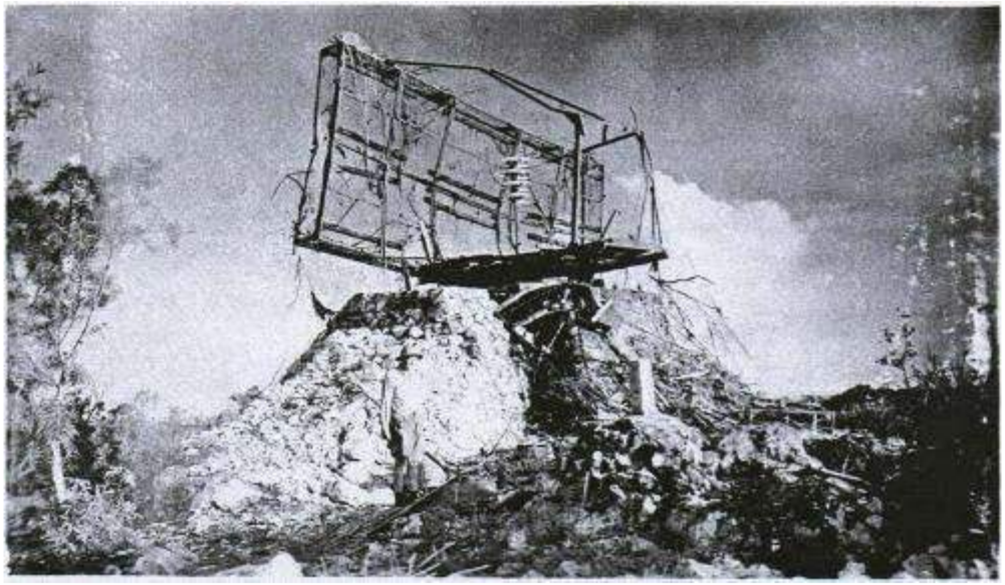


Figure 101. Destroyed Mark 1 Model 1 radar on Tinian (Photograph courtesy of Howard Cole).

On the Mount Lasso location, significant archeological remains of the radar emplacement would be expected from a Mark 1 Model 1 Modification 1 radar. The blogger photographed a large iron base with a motor that potentially enabled the 360-degree rotation of the antenna. Additionally, mesh wiring and iron framing onsite appear identical to those employed in the Mark 1 Model 1 Modification 1 “Attu” radar that was reported to have been on Tinian by US intelligence (Figure 102). Large brown porcelain-appearing insulators likely employed in this radar variant were found onsite. There is excellent potential for future fieldwork as there appears to be a sizable portion of a Japanese Mark 1 Model 1 Modification 1 “Attu” radar, a similar improved variant to Saipan’s “Guadalcanal” radar, with significant archeological remains on site (Figure 103). Further identification and surveying of this location is needed, as well as the radar emplacement location in the south, which was identified in the intelligence report. The Mark 1 Model 2 or “Mobile Mattress” radar location and supporting structures also should be attempted to be located. There is much research and fieldwork potential for further surveying these locations.

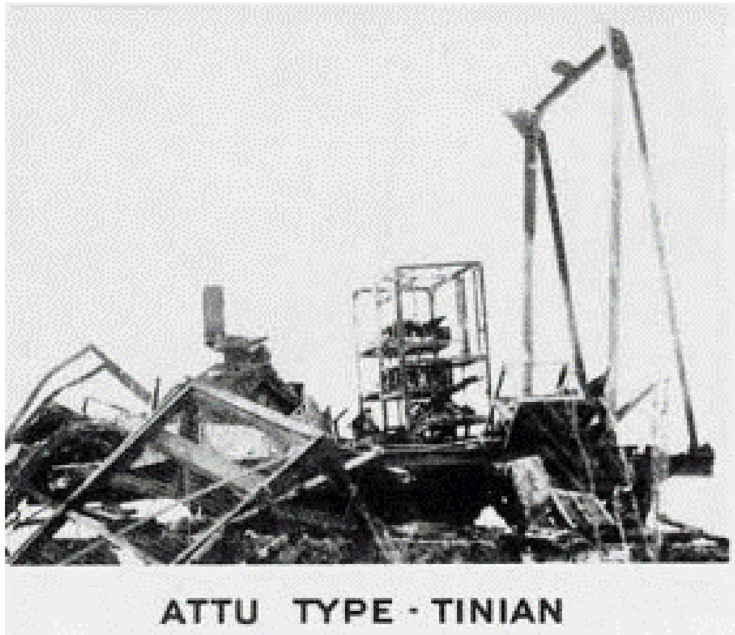


Figure 102. Destroyed Mark 1 Model 1 radar on Tinian from post-battle intelligence report (Division of Naval Intelligence 1945:28).

Figure 103. Photographs of destroyed Mark 1 Model 1 radar on Tinian (Images courtesy of Howard Cole, from February 2008. http://hiketinian.blogspot.com/2008/02/tinians-japanese-radar.html).

Chapter 6 Conclusion

This thesis aimed to research Japanese radar in the Pacific during the Second World War, using its effectiveness during the battle for Saipan as the case study. Radar is one of the most significant technological advancements Imperial Japan made during the War. Still, it remains nearly forgotten in the modern historical narrative of the war. To help change that perspective, this thesis provided archeological and historical evidence of the existence and effectiveness of four radar emplacements on the island of Saipan and two on nearby Tinian.

6.1. Historical Research Results

The historical research uncovered that Japanese radar technology and doctrine were far more advanced than previously suspected. In almost all narratives of the Pacific War, Imperial Japanese radar technology was dismissed as being years behind the Allies in innovation. Instead, the reality was, given their limited industrial capabilities compared to the US, Imperial Japan was able to develop a radar technology that surpassed that of even the British and, in some respects, the radar technologies of the US. Significantly, this was true with the Mark 4 Model 3 fire-control radar. The comparable fire-control radar that the US had was the SCR-268, which was massive to employ, with the antenna alone being 40 ft. long and 10 ft. high. Additionally, the SCR-268 radar could not be easily moved as the module was nearly 60,000 lbs., requiring four trucks compared to the Japanese Mark 4 Model 3's 1,000 lbs. (Henney 1945:103). Given its size, it offered a massive target and was easy for Japanese forces to jam. The British monostatic SLC radar that the Mark 4 Model 3 was inspired by had become vastly outdated by the improved Japanese radar. Imperial Japan had so advanced the radar that it was set to a bistatic function where the transmitter and receiver were in separate locations, making it less vulnerable to jamming. Most importantly, the Japanese enabled automatic tracking while the British SLC radar had to manually track a target through a radar operator, losing accuracy (Wilcox 2014). The Americans would only surpass Japanese land-based fire-control radar technology in the Pacific in late 1944 by employing the SCR-584 fire-control radar that operated through the more accurate microwave technology (Brown 1999:72).

Saipan offered the perfect case study on the effectiveness and accuracy of the Mark 4 Model 3 fire-control radar, as nearly all US aircraft combat losses over Saipan during the battle were through anti-aircraft fire (Appendix A). The located US aircraft losses were also determined to be within only a few miles of the suspected Japanese Mark 4 Model 3 fire-control radar range. Additionally, all US aircraft are within clear line of sight of Radar Hill in Tanapag Harbor. An optimal field of fire was available to detect the US aircraft over Tanapag Harbor for the attached anti-aircraft emplacements to destroy their targets. Through extensive archival research, it was revealed that US military intelligence was unaware that the Japanese had any fire-control radar capability before the Battle for Saipan. Given this void of intelligence, US Navy commanders had their aircraft bomb Tanapag Harbor and unknowingly fly directly over the Mark 4 Model 3 fire-control radar on Radar Hill and its adjacent anti-aircraft gun batteries. American aviators who flew over the objective those initial days of the attack reported "heavy and accurate" Japanese flak over Tanapag Harbor (USS *Lexington* 1944a). The Japanese radar was never severely damaged and could have been operating until 3 July 1944, when Radar Hill was captured, or until its oscillator tubes were damaged. From 11 June 1944 to 9 July 1944, there were 81 US aircraft lost over Saipan. Sixteen of them were likely lost to AA, having been directly noted in their circumstances, with the assistance of the Mark 4 Model 3 fire-control radar (Appendix A). Twelve of the US aircraft losses alone were noted as having been lost to Japanese AA fire on 11 June 1944 over the objective of Tanapag Harbor and likely the Mark 4 Model 3 fire-control radar (Appendix B). This was the highest loss rate to Japanese land-based AA fire up until that point in the war. Given their downed location and date, a total of 30-40 US aircraft are suspected to have been struck by Japanese AA, with the assistance of the Mark 4 Model 3 fire-control radar.

Utilizing ArcGIS as a tool for developing predictive models, the fields of fire of Japanese anti-aircraft units on Saipan were established to show the highest concentration of fire and correlate this to the downed locations of US aircraft (Figure 65). The highest concentration of Japanese AA fire was established to be off Mañagaha Island and the adjacent area, including the reef and the area directly beyond. The highest concentration of Japanese AA has the suspected submerged location of an SBD-5 Dauntless inside its area. Additionally, a submerged TBM Avenger is located approximately 0.5 mi. south of the highest concentration of Japanese AA fire. Also, there is a suspected crash site location of a US aircraft propeller, believed to be from an F6F-3 Hellcat, located approximately 0.6 mi. east of the highest concentration of fire. Lastly, the submerged F6F-3 Hellcat that has been the subject of DPAA MIA investigations from 2019-2023 is additionally located only 0.8 mi. from the highest concentration of AA fire. The highest concentration of Japanese AA fire is also only 3.0 mi. from the suspected Mark 4 Model 3 fire-control radar location, with a detection range of approximately 25 mi.

Historical research also revealed that the radar ranges on Saipan provided the Japanese defenders with an adequate warning. The information was represented through an ArcGIS analysis, demonstrating that at least three long-range Japanese early warning radar emplacements were located on Saipan and Tinian. The Mariana Islands (including Guam) acted as a layered radar detection for mainland Japan, with them being approximately only 1,200 mi. away. Early warning radar emplacements of Guam, Rota, Tinian, Saipan, and Pagan acted as a wall to detect a potential US attack (Hoffman 1950:3). On Saipan, the Japanese defenders had much warning of the invasion fleet through these radars on 11 June 1944, and could adequately prepare and range their anti-aircraft guns in time.

Japanese military radio communications had been intercepted, and the location of TF 58 was compromised and determined by the Japanese as "a Japanese language expert aboard *Lexington* intercepted radio traffic indicating the task force had been spotted; Mitscher went ahead and launched 208 Hellcat fighters and eight torpedo bombers from about 225 mi. off Saipan for the hour-long flight to the target" (Hallas 2019:67). US aircraft were launched after being compromised on 11 June 1944 at 1300 at 13.7° latitude 148.2° 305 km. from Saipan (USS *Lexington* 1944b:32). This location was just in range of the Mark 1 Model 3 search radar 1,300 yds, off the eastern end of Aslito Airfield. This very capable radar also worked as a rudimentary IFF for Japanese aircraft equipped with the Mark 6 Model 4 Type 3 radar, operating on 150 MHz. Thus, the echo ping received from the Mark 1 Model 3 radar would be significantly stronger than a typical aircraft contact. Due to being on the same frequencies, the Mark 1 Model 3 radar could also detect the US Mark III IFF up to 300 km. or more given atmospheric conditions, almost the exact location where the US fleet was reported compromised. Additionally, the early warning search radar emplacements on Naftan Peninsula, Tinian, and Radar Hill had an approximate operational range of 250 km., where the approaching US aircraft would further be picked up on their scopes and reported to the Japanese anti-aircraft emplacements to ready their guns and airfields to scramble their aircraft.

However, the Japanese could not rapidly scramble their aircraft with the given radar warning. Since the Japanese aircraft were degassed to prevent their explosion during a raid, they could not rapidly fuel up over 100 aircraft in one hour to scramble them to attack the approaching US aerial invasion force. It takes 30-60 minutes to refuel and rearm an A6M Zero from empty (Claringbould 2022). Only around 40 Japanese aircraft had time from that 1.5-hour radar detection countdown to be fueled and in the air. Approximately 60 aircraft were destroyed on Aslito Airfield, and the US was able to capture 24 Japanese aircraft in working order on Aslito Airfield (Headquarters, Expeditionary Troops, Task Force Fifty-Six 1944:5).

This thesis demonstrates that Saipan was the first Japanese defense to employ fire-control radar against US aircraft and that they established a layered radar detection system as a wall of early warning radar detection through the Mariana Islands. This detection system likely detected TF 58 as they moved towards the island chain.

Saipan acted as a pivot point in Japanese radar wartime development. After the battle in late 1944, Imperial Japan rapidly increased its production of early warning radar systems through its noted effectiveness. Its effectiveness urged the US development of an entire unit, Section 22, whose sole objective was detecting and destroying Japanese radar. After the battle, Imperial Japan would employ overlapping early warning radar detection throughout mainland Japan as it had first done at Saipan, preparing for US invasion and enabling the downing of 147 B-29 Superfortresses (Nijboer 2018:207). Without the technical specifications gained from the captured Mark 4 Model 3 fire-control radar on Saipan and the development of jamming countermeasures, that loss number would have been significantly higher.

After the war, much was concealed by US military leadership trying to save their careers and hide from the Soviet Union the effectiveness of Japanese radar to cover US technological blunders. These failures in US radar ranged from the Mark 4 Model 3 fire-control radar not having jamming countermeasures developed from July 1944 to May 1945 to the US Mark III IFF signals being triggered and intercepted by the Mark 1 Model 3 search radar and Mark 6 Model 4 Type 3 airborne radar (Hallion 2011).

6.2. Archaeological Research Results

Through extensive archival research, multiple WWII archeological sites were located on Saipan and surveyed as part of this research, including Naftan Peninsula, Mañagaha Island, and Radar Hill. The survey on the Naftan Peninsula revealed the remains of a Japanese radar emplacement, including a destroyed concrete building with a radar tower. Though the site had been previously surveyed by the Historic Preservation Office in 1996, its role was never identified. The building was destroyed, with large concrete segments scattered around the structure and US UXO nearby. Additionally identified were two anti-aircraft emplacements in a defensive posture around the radar. The guns were not yet in place during the battle, but all sites appear to be connected through underground electric cabling where a rudimentary fire-control function may have been established if they were. Most notable on the site was the location of a concrete radar tower. It is the only known type that remains on the island, as the other radar emplacements are believed to be more mobile. With the local foliage removed, the radar had a clear line of sight of the southern half of Saipan. Given its location, the Mark 1 Model 1 search radar likely quickly detected the invasion fleet on 11 June 1944, after the Aslito Airfield Mark 1 Model 3 radar detected the fleet. The emplacement on Radar Hill also acted as an overlapping detection layer for the later invasion fleet.

The Radar Hill archeological evidence was attempted to be surveyed comprehensively. Fortunately, the field where the Mark 4 Model 3 fire-control radar was likely located is on public land. The optimal requirements for fire-control radar and battery on an elevated field with a clear line of sight to its targets were easily met. It could have laid continuous, elevated, and unobstructed automatically radar-directed fire on US aircraft attacking Tanapag Harbor. The attacking US aircraft were within 3 mi. of attacking objectives over the harbor, as the attached 80 mm. AA guns had a maximum range of approximately 3.4 mi. The radar emplacement on Radar Hill additionally had a clear line of sight for radio communications for the dozens of anti-aircraft batteries below in Tanapag, transmitting the elevation, location, and direction of US aircraft through radio. At night, the searchlight function of the Mark 4 Model 3 fire-control radar with a blue lens filter could have been easily employed where all other anti-aircraft guns are cloned off it to focus fire on one specific target with deadly accuracy. Additionally, the archeological remains of a Mark 1 Model 1 search radar antenna were believed to have been located on the highest elevation point of Radar Hill. The IJN buildings on Radar Hill are on private land, and a comprehensive survey could not be completed. The initial survey located a one-story building and a separate two-story compound associated with the IJN. Both structures also had substantial evidence of combat. Given their complexity, they are likely a leadership headquarters of the IJN, which aided in the command and maintenance of the radar emplacements on Radar Hill. Interestingly, they also tell a second story that is less well-known and documented, which is related to CIA training in the 1950s and 1960s. More research on the site will reveal its layered history.

The archeological evidence uncovered on Mañagaha Island potentially shows the existence of the Japanese radar emplacement first observed by US submarine *Whale* in 1943. On the eastern portion of the island, through a terrestrial and snorkel survey, four Japanese light anti-aircraft guns were located in a defensive posture around what initially appeared to be a communications antenna. Through archival research, the site of this mast was almost precisely where early intelligence reports recorded it as a Japanese sound locator emplacement, the predecessor technology to radar. These features suggest the site is the location of a Mark 1 Model 3 aerial and surface search radar that replaced the sound locator on the island. The submerged mast was similar in height to the Mark 1 Model 3 radar's antenna, commonly used to detect submarines and surface vessels. It likely served to detect US submarines conducting surveillance and trying to sneak into Tanapag Harbor.

6.3. Future Archaeological Projects

This thesis analyzes the highest concentration of Japanese AA fire on Saipan, utilizing an ArcGIS model to determine the downing locations of US aircraft over Tanapag Harbor and across the island. From 11 June 1944 to 9 July 1944, an estimated 30-40 US aircraft were lost over Saipan to Japanese AA fire. Most US aircraft crashed in submerged locations around the island. Only 3-4 of these US aircraft currently have been located. The highest concentration of Japanese AA is within 1.0 mi. of these located wrecks, and much of this area has not been investigated or surveyed, particularly the reef and approximately 1.0 mi. west of the reef. A survey through magnetometer and side scan sonar remote sensing methodologies may locate additional downed submerged US aircraft. Some of the aircraft wreckage may still be confined to the coral reef. Due to the low altitude of the US aircrafts' initial attacks and their units' War Diaries, the distance US aircraft traveled after a fatal flak hit often appeared to be limited. Thus, this area with the highest concentration of Japanese flak is more likely to contain additional submerged US aircraft.

Future research related to the ArcGIS model could include plotting individual Japanese anti-aircraft weaponry from US intelligence map overlays to represent each gun's location, caliber, range, muzzle velocity, rate of fire, and maximum effective range. This work would be substantial, with over 100 reported AA guns on Saipan, but would provide a more accurate predictive model.

Additionally, a survey should be conducted on the Japanese radar emplacement located on Mount Lasso on Tinian. There are few archaeological remains of Japanese Mark 1 Model 1 search radar emplacements, and there appears to be substantial archeological evidence of the Tinian emplacement in situ. The antenna, mount, electrical motor, and additional equipment were on location when it was observed in 2008. It should be surveyed as it was likely used as a secondary radar emplacement that remained in operation throughout the battle for Saipan. The location on Mount Lasso is also much further north than was reported in intelligence reports, and it needs to be determined if this was faulty intelligence or if these were two separate radar emplacements.

Further attempts should be made to survey the IJN's two-story compound on private property. It is the most significant Japanese building still standing from the battle. The site appears to have been virtually undisturbed for multiple decades, and there are remaining artifacts within and around the building structures. The compound has multiple tool rooms and appears to be of a technical nature that could provide maintenance and command of the radar emplacements on Radar Hill. These structures likely aided the radar emplacements on Radar Hill and housed its operators and IJN leadership.

Particular attention should be given to the CIA's role in the building. All US engravings on the wall have an end date of 1962, the year the CIA ceased operations on the island from its headquarters a mile away on Capitol Hill. The site was likely used as a "black site" in CIA training operations after the US adopted the structures.

Much historical research remains to be learned on the forgotten narrative of Imperial Japanese radar at Saipan and throughout the Second World War. Further studies should be conducted throughout US aerial attacks on Imperial Japanese defensive fortifications of the Pacific War to determine the cause of detection and the effectiveness of radar, similar to this study. It is suspected that many of these Imperial Japanese defensive fortifications were alerted by radar and could scramble their aircraft and prepare their anti-aircraft guns accordingly. This will be particularly true after the battle for Saipan, which acted as a pivot point in Imperial Japanese radar technology.

Additionally, studies should be focused on the US failure of the Mark III IFF. This blunder allowed US aircraft to be easily compromised at great ranges by Japanese radar, where Saipan acted as potentially the first recorded US IFF compromise by Japanese radar of many more engagements. Certainly, much more historical and archeological research is needed to understand more about the forgotten narrative of Imperial Japanese radar at Saipan and throughout the Second World War.

REFERENCES

Aviation Archaeology Investigation and Research.
2023 *U.S. Navy Overseas Loss List 1941-1945*. Search USN Loss List 1941-1945. Aviation Archaeology Investigation and Research. <https://www.aviationarchaeology.com/dbSearchUSNLoss.asp>.

Bellamy, Craig
2020 *The Beginnings of the Secret Australian Radar Countermeasures Unit during the Pacific War.* College of Indigenous Futures, Arts and Society, Charles Darwin University, Casuarina, Australia.

Bonham, L.L.
1944 *Navy Department Report on Captured Japanese Cable. Naval Research Laboratory*, Anacostia Station, Washington, DC.

Bonham, L.L. and Lonsdale, E.M.
1945 *Laboratory Tests of Mark 4 Model 3 Radar Transmitter and Power Supply Units*. Radio Division- Search Radar Section. Naval Research Laboratory. Washington, DC.

Burns, Jason M.
2008 *Archaeological Survey of Tanapag Lagoon Saipan*, Commonwealth of the Northern Mariana Islands (2299_08016).

Cahill, William
2017 *Thirteenth Air Force Radio Countermeasures Operations, 1944-45*. Air Power History. Summer 2017 - Volume 64, Number 2.

Campbell, Douglas E.
2011a *Volume II: U.S. Navy, U.S. Marine Corps and U.S. Coast Guard Aircraft Lost During World War II - Listed by Squadron*. United Kingdom: Lulu.com.

2011b *Volume III: U.S. Navy, U.S. Marine Corps and U.S. Coast Guard Aircraft Lost During World War II - Listed by Squadron*. United Kingdom: Lulu.com.

2016 *Save Our Souls: Rescues Made by U.S. Submarines During World War II*. United States: Lulu.com.

U.S. Pacific Fleet and Pacific Ocean Areas (CINCPAC-CINCP
1943 *Item# 9,027. Subject: Organization and Operation of a Radar Lookout Station; estimated date August 1943, Source: Captured on Saipan.* CINCPAC-CINCPOA Translations.

1944a *G-2 Situation Map. No 2. Saipan Island*. Prepared by AC of S, G-2, V Amphibious Corps, 6 May 1944, from Photographs to 18 April 1944.

1944b *Japanese Operational Aircraft*, CINCPAC-CINCPOA 105-45. United States Pacific Fleet and the Pacific Ocean Areas, Headquarters of the Commander in Chief.

1944c *Methods of Flak Analysis, Flak Intelligence Memorandum Number 5*. CINCPAC-CINCPOA Bulletin No. 123-45. United States Pacific Fleet and the Pacific Ocean Areas, Headquarters of the Commander in Chief.

1945a *AA Defense of Saipan*, CINCPAC-CINCPOA Special Translation. United States Pacific Fleet and Pacific Ocean Areas.

1945b *Antiaircraft Defense Fortifications*, Special Translation number 62. CINCPAC-CINCPOA Bulletin No. 110-45. United States Pacific Fleet and the Pacific Ocean Areas, Headquarters of the Commander in Chief.

1945c Flak Intelligence Memorandum Number 1, *Japanese Anti-Aircraft Weapons*, CINCPAC-CINCPOA No. 13-45. United States Pacific Fleet and Pacific Ocean Areas, Headquarters of the Commander in Chief.

1945d Flak Intelligence Memorandum Number 4, *Japanese Anti-Aircraft Material*, CINCPAC-CINCPOA Bulletin No. 92-45. United States Pacific Fleet and Pacific Ocean Areas.

1945e *Forager Joint Staff Study*. United States Pacific Fleet and Pacific Ocean Areas.

1945f *Japanese Radio Communications and Radio Intelligence*. CINCPAC-CINCPOA Bulletin No. 5-45. United States Pacific Fleet and the Pacific Ocean Areas, Headquarters of the Commander in Chief.

1945g *Translations Interrogations Number 32*. CINCPAC-CINPOA Bulletin No. 147-45. United States Pacific Fleet and the Pacific Ocean Areas, Headquarters of the Commander in Chief.

Claringbould, Michael John
2022 *F4U Corsair Versus A6M Zero-sen: Rabaul and the Solomons 1943–44*. United Kingdom: Bloomsbury Publishing.

Cole, Howard
2008 *Tinian's Japanese Radar*. Blogspot. Accessed 30 October 2023. <http://hiketinian.blogspot.com/2008/02/tinians-japanese-radar.html>.

Com Gen 5th Phib Corps
1944a *G2 Report*, Phase 1 (Saipan). Com Gen 5th Phib Corps. War Diary.

1944b *Signal Officer's Report*, Phase 1 (Saipan). Com Gen 5th Phib Corps. War Diary. 25-36.

Defense POW/MIA Accounting Agency
2023a Defense POW/MIA Accounting Agency. *LTJG Arthur F Davis - Service Member Profile*. Accessed 30 October 2023. <https://dpaa-mil.sites.crmforce.mil/dpaaProfile?id=a0Jt000001nzVr0EAE>.

2023b Defense POW/MIA Accounting Agency. *LTJG Frank M Delgado - Service Member Profile*. Accessed 30 October 2023. <https://dpaa-mil.sites.crmforce.mil/dpaaProfile?id=a0Jt000001nzTSBEA2>.

2023c Defense POW/MIA Accounting Agency. *Lt James G Leonard – Service Member Profile*. <https://dpaa-mil.sites.crmforce.mil/dpaaProfile?id=a0Jt000001nzWTCEA2>.

2023d Defense POW/MIA Accounting Agency. *ENS Robert Dunn MCILWAINE – Service Member Profile.* <https://dpaa-mil.sites.crmforce.mil/dpaaProfile?id=a0Jt000001nzQB7EAM>.

Department of the Air Force
1990 *Environmental Impact Analysis Process, Saipan (PACBAR) Radar Mitigation Status Report*. Department of the Air Force.

Detroit Free Press
1944 *Ensign Nolte Casualty in Pacific Action.* Detroit Free Press, page 1, 29 July 1944. Detroit, MI. <https://www.newspapers.com/image/98150586/?terms=william%20francis%20nolte&match=1>.

Division of Naval Intelligence
1945 *Japanese Electronics*. United States, Photographic Intelligence Center, Division of Naval Intelligence, Navy Department.

Engineer, Expeditionary Troops (Task Force 56)
1944 *Report on Japanese Defensive Plan for the Island of Saipan*, Southern Marianas. Engineer, Expeditionary Troops (Task Force 56).

Foundation for German Communication and Related Technologies
2023 *RCM (also known ECM) versus Wurzburg (Würzburg)* <https://www.cdvandt.org/rcm_vs_wurzburg.htm>.

Graff, Cory

2009 *F6F Hellcat at War*. United States: Voyageur Press.

Galati, Gaspare
2015 *100 Years of Radar*. Austria, Springer International Publishing.

General Headquarters, United States Army Forces
1946 *Survey of Japanese Antiaircraft Artillery*. General Headquarters, United States Army Forces, Pacific.

Gibbs, Martin
2006 *Cultural Site Formation Processes in Maritime Archaeology: Disaster Response, Salvage and Muckelroy 30 Years on*. International Journal of Nautical Archaeology 35(1): 4.

Gould, Richard A., and N.M. School of American Research (Santa Fe (editors).
1983 *Shipwreck Anthropology*. University of New Mexico, Albuquerque.

Hallas, James H.
2019 *Saipan: The Battle That Doomed Japan in World War II*. United States, Stackpole Books.

Hallion, Richard
2011 *The Naval Air War in Korea*. United States: University of Alabama Press.

Headquarters, 27th Infantry Division
1944 *Report of Intelligence Activities, 27th Infantry Division, Saipan Operation.* Headquarters, 27th Infantry Division.

Headquarters, Expeditionary Troops, Task Force Fifty-Six
1944 *Forager Operation*, G-2 report. 31 August 1944. Appendix item, G-2 periodic reports, nos. 1 to 61 inclusive. Volume II. Headquarters, Expeditionary Troops, Task Force Fifty-Six.

Headquarters Northern Troops and Landing Force
1944 *Signal Report, Marianas Phase 1 (Saipan), Enclosure (G).* Headquarters Northern Troops and Landing Force.

Henney, Keith
1945 *The SCR 268 Radar*. Electronics. United States, McGraw-Hill Publishing Company.

Hoffman, Carl W
1950 *Saipan: The Beginning of the End*. Historical Branch, G-8 Division, Headquarters. U.S. Marine Corps.

1951 *The Seizure of Tinian*. Historical Branch, G-8 Division, Headquarters. U.S. Marine Corps.

Hoyt, Edwin P
2000 *Inferno: The Fire Bombing of Japan, March 9 - August 15, 1945*. United States: Madison Books.

HQ 27th Inf Division
1944 *Forager Operation*. G2. HQ 27th Inf Division.

Jeans, Roger B.
2017 *The CIA and Third Force Movements in China During the Early Cold War: The Great American Dream. Lexington Books, United States*.

Joint Intelligence Center Pacific Ocean Area (JICPOA)
1944a Translation of Captured Japanese Document. *Yokosuka Naval Communications School Publication: Reference Material on Electrical Ranging Technique, No. 4 Annes: Radar Wiring Diagrams.* Joint Intelligence Center, Pacific Ocean Areas, Navy Number 128 (One-Two-Eight)

1944b *Saipan, Tinian, Rota*, Joint Intelligence Center Pacific Ocean Areas, Information Bulletin. JICPOA Bulletin No. 34-44 10 March 1944.

1944c *Saipan*, Joint Intelligence Center Pacific Oceans Areas Target Survey. JICPOA Bulletin No. 66-44 10 May 1944

1944d *Saipan, Tinian, Rota, Joint Intelligence Center Pacific Ocean Areas, Information* Bulletin. JICPOA Bulletin No. 73-44 10 May 1944.

Joint Expeditionary Force (TF 51). Office of the Commander
1944 *Report of Capture of the Marianas*. Joint Expeditionary Force (TF 51). Office of the Commander.

Kreis, John, F.
2013 *Piercing the Fog: Intelligence and Army Air Forces Operations in World War II*. Military Studies Press.

Lardas, Mark
2019 *Japan 1944-45: Lemay's B-29 strategic bombing campaign*. Osprey Publishing.

Lepage, Jean-Denis
2020 *Torpedo Bombers, 1900–1950: An Illustrated History*. United Kingdom: Pen & Sword.

Simmonds, Ed
1995 *Echoes over the Pacific: An Overview of Allied Air Warning Radar in the Pacific, from Pearl Harbor to the Philippines campaign*. Banora Peninsula, NSW: E.W. & E. Simmonds.

2018 *Land Radar of the Japanese Navy*.
https://www17.big.or.jp/~father/aab/kikirui/navy_radar.html

Lotz, Dave
2018 *Patrol Area 14: US Navy World War II Submarine Patrols to the Mariana Islands*. United Kingdom, Xlibris US.

Macdonald, Rod
2021 *Task Force 58: The US Navy's Fast Carrier Strike Force that Won the War in the Pacific*. United Kingdom, Frontline.

McGillem, Clare. D.
2024 "telegraph." *Encyclopedia Britannica*, <https://www.britannica.com/technology/telegraph>.

McKinnon, Jennifer F., and Toni L. Carrell
2011 *Saipan WWII Invasion Beaches Underwater Heritage Trail*. Ships of Discovery and Exploration Research, Corpus Christi, Texas.

McKinnon, Jennifer F
2019 *CS19-0788 – DPAA-Lab Archaeological Site Survey Report* (ASSR).

MacLeod, Ian D
2006 In-*situ Corrosion Studies on Wrecked Aircraft of the Imperial Japanese Navy in Chuuk Lagoon, Federated States of Micronesia*. International Journal of Nautical Archaeology 35(1): 128–136.

Mansfield News-Journal
1944 *Navy Flier-Son of Mansfield Minister Missing in Action.* Mansfield News-Journal, page 1, July 24, 1944. Mansfield, OH. <newspapers.com/image/292460105/?terms=john%20r%20lindbeck&match=1>.

Military Intelligence Division
1945 *Japanese Defense Against Amphibious Operations*. War Department, Military Intelligence Division. Washington, DC.

Military Intelligence Division
1945a *Japanese Radar*. Ratel No. 8. Military Intelligence Division, War Department, Washington, DC.

1945b *Japanese Ground Equipment*, *The Japanese Army B Radars*, Number 18, Ratel No. 12. War Department, Military Intelligence Division. Washington, DC.

Morison, Samuel Eliot

1953 *New Guinea and the Marianas, March 1944-August 1944*. Little, Brown and Co. Boston, MA.

Mullis, Ina V. S.
1993 *Who Goes There - Friend or Foe? Friendly Fire Casualties*. Diane Publishing Company. Darby, PA.

Murphy, Larry
1983 *Shipwrecks as a Database for Human Behavioral Studies*. In Shipwreck Anthropology, edited by Richard A. Gould, pp. 65–90. University of New Mexico, Albuquerque.

Nakagawa, Yasuzo
1998 *Japanese Radar and Related Weapons of World War II*. United States, Aegean Park Press.

Nakajima, S
1992 *Japanese Radar Development Prior to 1945*. IEEE Antennas and Propagation Magazine 34, no. 6: 17–22.

National Archives and Records Administration
1944a *Huge Gasoline Fire: Japanese Ships & Small Craft Burn in Harbor Saipan*, July 15, 1944. National Archives at College Park, College Park, MD.

1944b *Invasion of Saipan: Japanese Radar & Installations; Unloading Operations on Pontoon Dock*, 22 July 1944. National Archives at College Park, College Park, MD.

1944c *Montage Destroyed Japanese Radar Tower / Saipan, Mariana Islands*, 22 July 1944. National Archives at College Park, College Park, MD.

1944d *Scenes of the Invasion of Saipan*, 11 August 1944. National Archives at College Park, College Park, MD.

Naval History and Heritage Command
2019a *Bunker Hill I* (CV-17). Naval History and Heritage Command. Accessed 30 October 2023. < https://www.history.navy.mil/research/histories/ship-histories/danfs/b/bunker-hill-i.html>.

2019b *Fanshaw Bay* (CVE-70). Naval History and Heritage Command. Accessed 30 October 2023. <https://www.history.navy.mil/content/history/nhhc/research/histories/ship-histories/danfs/f/fanshaw-bay.html>.

2019c *Kalinin Bay* (CVE-68). Naval History and Heritage Command. Accessed 30 October 2023. <https://www.history.navy.mil/content/history/nhhc/research/histories/ship-histories/danfs/k/kalinin-bay.html>.

Naval Research Laboratory
1943 *Japanese Radar Equipment C.E.E No. 211- Captured on Guadalcanal.* Radio Division-Search Radar Section. Naval Research Laboratory, Washington, DC.

1945a *Laboratory Tests of Mark 4 Model 3 Radar Transmitter and Power Supply Units*. Radio Division- Search Radar Section. Naval Research Laboratory, Washington, DC.

1945b *Technical Data on Japanese Radio and Radar Equipment*. Radio Division. Naval Research Laboratory. Washington, DC.

Navy Operations Specialist School Graduation Association
1980 *Glorious Navy Operations Officer*. August 1980.

Nippon Hoso Kyokai (NHK)
1944 *Japan News No. 219*. 10 August 1944. NHK. Tokyo, Japan.

Nijboer, Donald
2018 *Flak in World War II*. United States, Stackpole Books.

Nufer, Harold F.
1978 *Micronesia Under American Rule: An Evaluation of the Strategic Trusteeship* (1947-77). United States: Exposition Press.

Office of the Chief of Naval Operations
1945a *Counter Radar Measures and Deception Used by the US Navy in the Pacific, Excerpts from Aircraft Action Reports and Battle Narratives, September-November 1944.* Air Intelligence Group. Division of Naval Intelligence. Office of the Chief of Naval Operations. Navy Department. Washington, DC.

1945b *Japanese Guns Anti-Aircraft & Coastal Defense*. Air Intelligence Group, Division of Naval Intelligence, Office of the Chief of Naval Operations, Navy Department. Washington, DC.

1945c *Japanese Military Buildings*. Air Intelligence Group, Division of Naval Intelligence, Office of the Chief of Naval Operations, Navy Department.

Office of the Chief Signal Officer, Section 22
1945a Current Statement, *Radar Counter Measures*. General Headquarters, South-West Pacific Area - Office of the Chief Signal Officer Section 22. National Archives of Australia. Canberra, Australia.

1945b *Jap Radar*. General Headquarters, South-West Pacific Area, Office of the Chief Signal Officer, Section 22. National Archives of Australia. Canberra, Australia.

1945c *Japanese Radar*. General Headquarters, South-West Pacific Area - Office of the Chief Signal Officer Section 22. National Archives of Australia. Canberra, Australia.

1945d *Section 22.* Roll A7237. General Headquarters, South-West Pacific Area - Office of the Chief Signal Officer Section 22. Maxwell Air Force Base, AL.

Office of the Chief Signal Officer, Technical Liaison and Investigation Division
1944 *Theoretical Notes of the Japanese Army Radar (Tachi 22).* General Headquarters, United States Army Forces, Pacific, Office of the Chief Signal Officer, Technical Liaison and Investigation Division, Advance Echelon.

Pacific Wrecks
2023 *B-24J-50-CO 'Cloudy Joe' Serial Number 42-73499*. World War II, the Pacific War, and the Korean War. Accessed 30 October 2023. <https://pacificwrecks.com/aircraft/b-24/42-73499.html>.

Peattie, Mark, and Evans, David C.
2015 *Kaigun: Strategy, Tactics, and Technology in the Imperial Japanese Navy, 1887-1941*. United States, Naval Institute Press.

Pęczkowski, Robert and Juszczak, Artur
2007 *Douglas SBD Dauntless*. Poland: STRATUS for Mushroom Model Publications, 2007.

Polmar, Norman and Genda, Minoru
2006 *Aircraft Carriers: A History of Carrier Aviation and Its Influence on World Events, Volume I: 1909-1945*. United Kingdom: Potomac Books.

Price, Alfred
1984 *The History of US Electronic Warfare: The Years of Innovation*. United States, Association of Old Crows.

RAAF Command Headquarters
1944 *Japanese Employment of Radar*. RAAF Command Headquarters.

1945 *RCM [Radio Counter Measure] Current Statements - Section 22.* RAAF Command Headquarters.

RF Wireless World
2012 *Active Radar Vs Passive Radar-Difference Between Active Radar and Passive Radar*. <https://www.rfwireless-world.com/Terminology/Active-radar-vs-Passive-radar.html>.

Skolnik, Merrill I.
2023 *Radar*. Encyclopedia Britannica. Accessed 31 October 2023. https://www.britannica.com/technology/radar/Transmitters.

Smith, Peter C.
2014 *Mitsubishi Zero: Japan's Legendary Fighter*. United Kingdom: Pen & Sword Books Limited.

Stewart, William H.
1985 *Ghost Fleet of the Truk Lagoon, Japanese Mandated Islands: An Account of "Operation Hailstone,"* February 1944. United States, Pictorial Histories Publishing Company.

Schiffer, Michael B.
1996 *Formation Processes of the Archaeological Record*. University of Utah Press, Salt Lake City.

Southwest Pacific Area, Office of the Chief Signal Officer, Section 22
1944 *Japanese Radar and Radio Activities in the Southwest Pacific Area.* General Headquarters, Southwest Pacific Area, Office of the Chief Signal Officer, Section 22.

Stafford, Edward
1962 *The Big E: The Story of the USS Enterprise*. Washington, DC Random House.

Stille, Mark
2012 *Imperial Japanese Navy Submarines 1941–45*. United Kingdom: Bloomsbury Publishing.

2014 *The Imperial Japanese Navy in the Pacific War*. United Kingdom, Bloomsbury Publishing.

Sub-Committee of the Joint Committee on New Weapons and Equipment
1943 *U.S. Radar Operational Characteristics of Radar Classified by Tactical Application.* Washington, DC.

Swords, Séan S.
1986 *Technical History of the Beginnings of Radar*. United Kingdom, P. Peregrinus.

Task Force Fifty-Two, Office of the Commander
1944 *Commander Task Force Fifty-Two Attack Order No. All-44*. US Pacific Fleet, Task Force Fifty-Two, Office of the Commander.

Taylor, Dennis and Westcott, C. H.
1948 *Principles of Radar*. United Kingdom, University of Cambridge Press.

The Army Air Forces Board
1945 *Countermeasures Against Gun-Laying Radar.* Army Air Forces Board Project No. 3681C373.1. The Army Air Forces Board. Orlando, Florida.

The Blueprints
2023a *Grumman*. The Blueprints. <https://www.the-blueprints.com/blueprints/ww2planes/ww2-grumman/>.

2023b *Dauntless*. The Blueprints. < https://www.the-blueprints.com/blueprints/ww2planes/ww2-douglas/79025/view/douglas_sbd-5_dauntless/**>.**

2023c *Avenger*. The Blueprints. < https://www.the-blueprints.com/blueprints/ww2planes/ww2-grumman/18321/view/grumman_tbm_avenger/>.

2023d *Wildcat*. The Blueprints. <https://www.the-blueprints.com/blueprints/ww2planes/ww2-grumman/18321/view/grumman_tbm_avenger/>.

The Drumright Derrick
1944 *Oilton Youth Dies in Ocean Plane Crash.* The Drumright Derrick, page 1, July 28, 1944. Drumwright, OK.
<https://www.newspapers.com/image/592360422/?terms=melvin%20roach&match=1>.

The First Battalion, 24th Marines
2021a *Battle Narrative Saipan: D+18. 3 July 1944*. 1, June 15, 2021. <https://1-24thmarines.com/the-battles/saipan/d18/>.

2021b *Battle Narrative Saipan: D+20. July 5, 1944*. 1, June 15, 2021. <https://1-24thmarines.com/the-battles/saipan/d20/>.

The Joint Chiefs of Staff
1943 *U.S. Radar*, Operational Characteristics of Radar Classified by Tactical Application, Radar Research and Development Sub-Committee of the Joint Committee on New Weapons and Equipment.

United States Fleet Headquarters of the Commander in Chief Navy Department
1945 *Radio Operator's Manual, Radar Bulletin No. 3.* United States Fleet Headquarters of the Commander in Chief Navy Department, Washington, DC.

United States Pacific Fleet and Pacific Ocean Areas. Headquarters of the Commander-in-Chief
1944 *Land-Based AA Gunnery Manual*, Special Translation Number 61. United States Pacific Fleet and Pacific Ocean Areas. Headquarters of the Commander in Chief.

US Naval Technical Mission to Japan

1945 *Japanese Antennae.* Intelligence Targets Japan. US Naval Technical Mission to Japan. United States, Operational Archives, US Naval History Division.

1946a *Japanese Land-based Radar*. Reports of the US Naval Technical Mission to Japan. United States, Operational Archives, US Naval History Division.

1946b *Japanese Anti-Aircraft Fire-control*, Intelligence Targets Japan. US Naval Technical Mission to Japan. United States, Operational Archives, US Naval History Division.
US Naval Technical Mission to Japan.

1946c *Japanese Naval Guns*, Intelligence Targets Japan. US Naval Technical Mission to Japan. United States, Operational Archives, US Naval History Division.

US Strategic Bombing Survey
1944 *Weekly Intelligence Bulletins*, Vol. I, Nos. 1 to 52, 14 July 1944 to 9 July 1945. Report No. 11-c (3), USSBS Index Section 6. United States Pacific Fleet and Pacific Ocean Areas.

1945a *Interrogation No. 183, Personnel Interrogated: Major Yamamoto, Subject: Effect of American Radar Counter Measures on Anti-aircraft Division*. US Strategic Bombing Survey (Pacific).

1945b *Interrogation No. 188, Personnel Interrogated: Lt. Col Suzuki and Lt. Col. Kamiko, Subject: Effect of American Radar Counter Measures on Anti-aircraft Division*. US Strategic Bombing Survey (Pacific).

1945c *Interrogation No. 293, Personnel Interrogated: 1LT Sekiguchi, Subject: Effect of American Radar Counter Measures on Anti-aircraft Division*. US Strategic Bombing Survey (Pacific).

1945d *Interrogation No. 477, Personnel Interrogated: Colonel Kinji Satake, Subject: Army Radar Applied Tactics.* Strategic Air Division. Headquarters. US Strategic Bombing Survey (Pacific).

1945e *Interrogation No. 491, Personnel Interrogated: Major Yamamoto, Subject: Effect of American Radar Counter Measures on Anti-aircraft Division.* US Strategic Bombing Survey (Pacific).

1945f *Typical Japanese Military Targets, Part II-Radio and Radar*. Joint Target Group, General Analysis. Strategic Bombing Survey. Washington DC. 1-2.

USS *Alabama*

1944 *Description of Intercepted Emissions, Japanese Radar and Radio*. 13 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1070, Micro Serial Number 80337. National Archives Catalogue ID 4697018 <https://www.fold3.com/image/279808365/report-of-bombardment-of-saipan-island-marianas-on-61344-page-19-us-world-war-ii-war-diaries-1941-19?terms=saipan,japanese,radar>.

USS *Bunker Hill* (CV-17)
1944a USS *Bunker Hill* (CV-17). 1 June to 30 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1035, Micro Serial Number 78016. National Archives Catalogue ID 4697018 < https://www.fold3.com/image/277153108/war-diary-61-3044-page-10-us-world-war-ii-war-diaries-1941-1945>.

1944b USS *Bunker Hill* (CV-17). Rep of Air Attack on Jap Task Force on 20 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1043, Micro Serial Number 78960. National Archives Catalogue ID 4697018 < https://www.fold3.com/image/277725719/rep-of-air-attack-on-jap-task-force-on-62044-west-of-marianas-islands-page-32-us-world-war-ii-war-di>.

USS *Cleveland*
1944 *Report of Bombardments of Japanese Installations on Saipan Island*, Marianas - Period 6/25/44 to 7/7/44. USS *Cleveland*.

USS *Coral Sea* (CV-43)
1944 USS *Coral Sea* (CV-43). 14 June to 21 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1024, Micro Serial Number 77346. National Archives Catalogue ID 4697018 < https://www.fold3.com/image/276916259/act-rep-of-ops-during-assault-occupation-of-saipan-is-marianas-614-2144-page-8-us-world-war-ii-war-d>.

USS *Corregidor* (CVE-58)
1944 USS *Corregidor* (CVE-58). 10 June to 28 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1030, Micro Serial Number 77692. National Archives Catalogue ID 4697018 <https://www.fold3.com/image/277003066/act-rep-of-ops-610-2844-marianas-operation-page-11-us-world-war-ii-war-diaries-1941-1945?terms=hudson%2Cuss%2Ccorregidor>.

USS *Cowpens* (CVL-25)
1944 USS *Cowpens* (CVL-25). 1 June to 30 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1035, Micro Serial Number 79153. National Archives Catalogue ID 4697018 < https://www.fold3.com/image/277716712/war-diary-61-3044-page-6-us-world-war-ii-war-diaries-1941-1945>.

USS *Enterprise* (CV-6)
1944a USS *Enterprise* (CV-6). 1 June to 30 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1057, Micro Serial Number 79537. National Archives Catalogue ID 4697018 < https://www.fold3.com/image/276943421/war-diary-61-3044-page-4-us-world-war-ii-war-diaries-1941-1945>.

1944b USS *Enterprise* (CV-6). 11 June to 29 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1976, Micro Serial Number 151928. National Archives Catalogue ID 4697018 <https://www.fold3.com/image/301618847/report-of-air-operations-against-the-marianas-islands-611-2944-including-a-a-actions-on-615-1944-and>.

USS *Essex* (CV-9)
1944 USS *Essex* (CV-9) Action Report. 22 February 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 0861. National Archives Catalogue ID 67282 <https://www.fold3.com/image/272842083/act-rep-attack-on-saipan-tinian-22244-page-19-us-world-war-ii-war-diaries-1941-1945>.

USS *Hornet* (CV-8)
1944 USS *Hornet* (CV-6). 11 June to 24 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1069, Micro Serial Number 80241. National Archives Catalogue ID 4697018 < https://www.fold3.com/image/279824384/report-of-air-strikes-against-the-marianas-and-bonin-islands-and-action-against-jap-fleet-during-the>.

USS *Langley* (CV-27)
1944 USS *Langley* (CV-27). 1 June to 30 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1051, Micro Serial Number 79179. National Archives Catalogue ID 4697018 < https://www.fold3.com/image/277058686/war-diary-61-3044-page-5-us-world-war-ii-war-diaries-1941-1945>.

USS *Lexington* (CV-16)
1944a USS *Lexington* (CV-16). 11 June to 20 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1042, Micro Serial Number 78601. National Archives Catalogue ID 4697018 < https://www.fold3.com/image/277016499/act-rep-of-attacks-on-the-marianas-611-1944-in-support-of-the-occupation-of-saipan-the-engagement-wi>.

1944b USS *Lexington* (CV-16). 1 June to 30 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1032, Micro Serial Number 77870. National Archives Catalogue ID 4697018 <https://www.fold3.com/image/277722139/war-diary-61-3044-action-report-p-21-35-page-9-us-world-war-ii-war-diaries-1941-1945>.

USS *Louisville* (CA-28)
1944 USS *Louisville* (CA-28). 1 June to 31 July 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1119, Micro Serial Number 84192. National Archives Catalogue ID 4697018 <https://www.fold3.com/image/279764323/report-of-operations-in-support-of-occupation-of-saipan-and-tinian-islands-marianas-june-and-july-19>.

USS *San Jacinto* (CVL-30)

1944 USS *San Jacinto* (CVL-30). 6 June to 30 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1061, Micro Serial Number 79771. National Archives Catalogue ID 4697018 <https://www.fold3.com/image/279750993/rep-of-ops-against-saipan-tinian-guam-is-marianas-during-the-period-66-3044-page-18-us-world-war-ii->.

USS *Wasp* (CVE-66)
1944 USS *Wasp* (CVE-66). 6 June to 27 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1022, Micro Serial Number 77173. National Archives Catalogue ID 4697018 < https://www.fold3.com/image/277710911/act-rep-of-first-phase-of-marianas-op-act-against-jap-surface-forces-during-66-2744-page-22-us-world>.

USS *White Plains* (CVE-66)
1944 USS *White Plains* (CVE-66). 1 June to 30 June 1944. World War Two War Diaries, Other Operational Records and Histories. RG 38. Roll 1058, Micro Serial Number 79682. National Archives Catalogue ID 4697018 < https://www.fold3.com/image/276943421/war-diary-61-3044-page-4-us-world-war-ii-war-diaries-1941-1945>.

U.S. Patrol Squadrons
VP-16 Mishap Summary Page - VP Patrol Squadron. VPNAVY. Accessed 30 October 2023. https://www.vpnavy.org/vp16_mishap.html.

War Department
1944 TM-E 30-480: *Handbook on Japanese Military Forces.* War Department. Washington, DC.

Wilcox, David
2014 *Army Radar: The Story of Its Development and Employment in World War II.* United Kingdom: Tommies Guides.

Wilkinson, Roger
1946a *A Short Survey of Japanese Radar — I*. Volume I. Operations Analysis, AC/AS-3 Headquarters, Army Air Forces. Washington, DC.

1946b *A Short Survey of Japanese Radar — II*. Volume II. Operations Analysis, AC/AS-3 Headquarters, Army Air Forces. Washington, DC.

1946c *A Short Survey of Japanese Radar — III.* Volume III. Operations Analysis, AC/AS-3 Headquarters, Army Air Forces. Washington, DC.

World War Photos
2023 World War Photos. *Nakajima B5N.* <https://www.worldwarphotos.info/gallery/japan/aircrafts/b5n/>.

XXIV Corps

1944 *Participation in the Marianas Operation, United States Army Forces in the Central Pacific Area*. Volume II. XXIV Corps.

Yoshida, Akihiko
2013. *The Japanese Submarine Force and World War II*. United States: Naval Institute Press. Annapolis, MD.

APPENDIX A: US AIRCRAFT LOSSES OVER OR NEARBY SAIPAN

11 June 1944-9 July 1944,
29 May 1944,
22 February 1944

11 June 1944-9 July 1944

Losses: 81 Aircraft

Grumman F6F-3 Hellcat: 23
Grumman TBM-1C Avenger: 23
Douglas SBD-5 Dauntless: 7
Grumman FM-2 Wildcat: 13
General Motors TBF-1C Avenger: 10
Martin PBM-3(D) Mariner: 3
Stinson OY-1 Sentinel: 2
Curtiss SOC-1 Seagull: 1

*US aircraft losses determined through *Aviation Archaeology* database

Crash	**Type**	**BN**	**Squad**	**From**	**Down**	**Pilot**	**Pilot fate**	**Loss Circumstances**	**Source of Loss Circumstance**
440611	F6F-3	42522	VF-8	USS BUNKER HILL (CV-17)	SAIPAN	CAPT W.M. COLLINS	S	"One of our fighters landed in the water alongside a destroyer of this formation. He had been shot up and could not land aboard. The pilot was recovered." (Fold3 2023)?	https://www.fold3.com/image/277153108/war-diary-61-3044-page-10-us-world-war-ii-war-diaries-1941-1945

440611	F6F-3	41746	VF-32	USS LANGLEY (CVL-27)	SAIPAN	LTJG DONALD E. REEVES	M	"…recovered by "Able" method 10 VF from Saipan fighter sweep VF-2, bureau No. 41746, Lt.(j.g.) D.E. Reeves, 250616, U.S.N.R., pilot, missing" (Fold3 2023). "…downed in same strike as LTJG Kenney" (Hallas 2019:68).	https://www.fold3.com/image/277058686/war-diary-61-3044-page-5-us-world-war-ii-war-diaries-1941-1945 (Hallas 2019:68)
440611	F6F-3	40676	VF-16	USS LEXINGTON (CV-16)	SAIPAN	LTJG WILLIAM E. BURCKHALTER	D	"All types of AA fire from Saipan were intense, and AA shot down one plane of VF-16" (Fold3 2023). "…took a hit in the engine during a strafing run over Aslito Field. He made a smooth landing 6 miles offshore, but as he left the cockpit his parachute shrouds extended back into the cockpit as the Hellcat sank under the surface, dragging him to his death" (Hallas 2019:68).	https://www.fold3.com/image/277016499/act-rep-of-attacks-on-the-marianas-611-1944-in-support-of-the-occupation-of-saipan-the-engagement-wi (Hallas 2019:68)
440611	F6F-3	26029	VF-31	USS CABOT (CVL-28)	SAIPAN	ENS R.G. WHITWORTH	S	"…made forced landing in water and was later rescued uninjured by Thatcher. Forced landing caused by enemy AA fire over Saipan" (Fold3 2023).	https://www.fold3.com/image/277058686/war-diary-61-3044-page-5-us-world-war-ii-war-diaries-1941-1945
440611	F6F-3	41240	VF-8	USS BUNKER HILL (CV-17)	SAIPAN	LT DONALD E. CARNEY	M	"Another fighter is missing and is reported to have been shot down in flames over the target. The pilot was Lt. D.E. Carney, A-V(N), File #86192, USNR" (Fold3 2023).	https://www.fold3.com/image/277153108/war-diary-61-3044-page-10-us-world-war-ii-war-diaries-1941-1945

440611	F6F-3	41285	VF-10	USS ENTERPRISE (CV-6)	SAIPAN	LTJG M.P. LONG	S	"…at 1704 fighter sweep returned with two fighters missing, the pilot of one was rescued by the Hull" (Fold3 2023).	https://www.fold3.com/image/276943421/war-diary-61-3044-page-4-us-world-war-ii-war-diaries-1941-1945
440611	F6F-3	41651	VF-15	USS ESSEX (CV-9)	SAIPAN	LTJG LEO T. KENNEY	D	"…was hit during his dive and never pulled out" (Hallas 2019:68).	(Hallas 2019:68)
440611	F6F-3	25768	VF-2	USS HORNET (CV-12)	SAIPAN	LT HOWARD B. DUFF	M	"Recovered 15 VF of the fighter sweep, one plane having been forced to Port Apra as a result of the damage sustained from AA fire. Pilot was seen swimming in the water after having landed his plane" (Fold3 2023).	https://www.fold3.com/image/279824384/report-of-air-strikes-against-the-marianas-and-bonin-islands-and-action-against-jap-fleet-during-the
440611	F6F-3	66069	VF-25	USS COWPENS (CVL-25)	SAIPAN	ENS PAUL AARON PARKER	M	"Flying off Cowpens, he disappeared after an encounter with some Zekes" (Hallas 2019:68).	(Hallas 2019:68)
440611	F6F-3	42322	VF-10	USS ENTERPRISE (CV-6)	SAIPAN	LTJG RICHARD W. MASON	S	"…at 1704 fighter sweep returned with two fighters missing, the pilot of one was rescued by the Hull" (Fold3 2023).	https://www.fold3.com/image/276943421/war-diary-61-3044-page-4-us-world-war-ii-war-diaries-1941-1945
440611	F6F-3	41154	VF-8	USS BUNKER HILL (CV-17)	SAIPAN	LT BOYLES	S	"One of our fighters landed in the water alongside a destroyer of this formation. He had been shot up and could not land aboard. The pilot was recovered." (Fold3 2023)?	https://www.fold3.com/image/277153108/war-diary-61-3044-page-10-us-world-war-ii-war-diaries-1941-1945

440611	F6F-3	41646	VF-3	USS LANGLEY (CVL-27)	SAIPAN	LT MAURICE N. WICKENDOLL	S	"…made forced landing in water and rescued uninjured by Thatcher. Forced landing caused by damage to engine from enemy AA fire over Saipan" (Fold3 2023).	https://www.fold3.com/image/277058686/war-diary-61-3044-page-5-us-world-war-ii-war-diaries-1941-1945
440611	SBD-5	36258	VB-16	USS LEXINGTON (CV-16)	SAIPAN	LT B.T. MENNIS	S	"During the recovery at 1131K, one of the VB planes had a barrier crash and was jettisoned due to damage sustained. Neither the pilot or crewman was injured" (Fold3 2023).	https://www.fold3.com/image/277016499/act-rep-of-attacks-on-the-marianas-611-1944-in-support-of-the-occupation-of-saipan-the-engagement-wi
440612	F6F-3	66113	VF-16	USS LEXINGTON (CV-16)	SAIPAN	LTJG CLEVELAND LEROY NULL	S	"1228K Picked up Lieutenant (j.g.) C.L. Null, A-V(N), USNR, uninjured. Null is attached to the USS Lexington" (Campbell 2011:372).	(Campbell 2011:372)
440612	F6F-3	41105	VF-16	USS LEXINGTON (CV-16)	SAIPAN	LTJG JOHN R. LINDBECK	M	"Mrs. Lindbeck had received a letter from Lieut. Lindbeck telling of seeing his plane go down and stating the plane was not high enough for him to bail out" (Newspapers 2023).	https://www.newspapers.com/image/292460105/?terms=john%20r%20lindbeck&match=1
440612	F6F-3	42863	VF-51	USS SAN JACINTO (CVL-30)	SAIPAN	ENS ROBERT DUNN MCILWAIN	D	"On June 12, 1944, he was killed in action while flying a combat mission over Saipan Island. While strafing an enemy airfield, his aircraft (Bureau Number 42863) was hit by anti-aircraft fire and disintegrated in midair. Ensign	https://dpaa-mil.sites.crmforce.mil/dpaaProfile?id=a0Jt000001nzQB7EAM

								McIlwaine was killed in the incident" (DPAA 2023).	
440612	F6F-3	41643	VF-15	USS ESSEX (CV-9)	SAIPAN	LT MELVIN CLEVELAND ROACH	D	"On June 12, 1944, he took off from the deck of the carrier and proceeded for a distance of about one mile when his plane was observed to descend, exploding upon crashing into the sea. A search of the area disclosed no evidence of the pilot, and it is apparent that he sank with the plane. The cause of the crash is not known" (Newspapers 2023).	https://www.newspapers.com/image/592360422/?terms=melvin%20roach&match=1
440612	SBD-5	36078	VB-10	USS ENTERPRISE (CV-6)	SAIPAN	LT JAMES G. LEONARD	M	"On June 12, 1944, an SBD-5 Dauntless (Bureau Number 36078), with a crew of two, took off from the USS Enterprise for strike against enemy shipping at Tanapag Harbor and gun emplacements southwest of Aslito airfield, both on the island of Saipan. This Dauntless was hit by antiaircraft fire and crashed into the sea due west of Mamagasa Island. No one was seen leaving the plane following the crash. Both members of the crew were reported missing and neither was seen again" (DPAA 2023).	https://dpaa-mil.sites.crmforce.mil/dpaaProfile?id=a0Jt000001nzWTCEA2
440612	TBM-1C	16918	VT-15	USS ESSEX (CV-9)	SAIPAN	LTJG JOHN B. CHAMBERS	S		
440612	TBF-1C	24463	VT-25	USS COWPENS (CVL-25)	SAIPAN	LT COMDR R.H. PRICE	S	"…landed in water near scene of enemy convoy bombing action. Plane lost... Returning air group reported life raft successfully dropped to Lt. Comdr. Price and he was observed to swim to it and	https://www.fold3.com/image/277716712/war-diary-61-3044-page-6-us-world-war-ii-war-diaries-1941-1945

								get in. He appeared uninjured" (Fold3 2023).	
440612	SBD-5	35955	VB-16	USS LEXINGTON (CV-16)	SAIPAN	LTJG GUILFORD F. BRANSON	D	"0836K Recovered Lieutenant (j.g.) G.F. Branson Jr., A-V(N), USNR, attached to USS Lexington. The officer was apparently dead when recovered. Both men were lowered below through the forward escape trunk and groups of five men started working on each man attempting to restore circulation and respiration; adrenalin was administered to each man. Unfortunately, neither man recovered. Treatment was continued until rigor mortis set in" (Campbell 2011:372).	(Campbell 2011:372)
440613	F6F-3	41926	VF-14	USS WASP (CV-18)	SAIPAN	ENS MULARSKI	S		
440613	F6F-3	42534	VF-10	USS ENTERPRISE (CV-6)	SAIPAN	ENS MURPHY D. POWELL	M	“12 VF - 1 VF plane piloted by Ens. M.D Powell, Jr., USNR (VF-10) missing in action and pilot believed dead; area south of CHARAN-KANOA airfield strafed. No bombs dropped” (CV6 2023).	http://www.cv6.org/ship/logs/action19440606-0017.htm#0615
440613	SBD-5	36289	VB-10	USS ENTERPRISE (CV-6)	SAIPAN	COMDR. WILLIAM.I. MARTIN		"Martin could see gunfire winking at him as his TBF Avenger nosed into a dive by the radio towers off the northern end of the Charan Kanoa airstrip. At 3,500 feet, Martin pressed the electric bomb release and was pulling the backup manual release when something slammed into the plane with "a teeth-shattering jolt." As the aircraft tumbled, he found himself on his back. "I knew we were crashing," he said. "I felt a heat wave go past me	(Hallas 2019:70-71)

								and thought the plane was in flames. "Flying off Martin's wing, Avenger pilot Gibby Blake watched in horror as his skipper's aircraft came apart. "His plane did a tumbling act with his whole tail section blown off," reported Blake. Martin groped for the microphone to tell Aviation Radioman 1st Class Jerry T. Williams and Aviation Ordnanceman 2nd Class Wesley R Hargrove to jump but couldn't find it as the plane plunged toward the lagoon. It probably didn't matter. A 5-inch shell had hit behind the cockpit, cutting the aircraft in half. On a count of one, Martin released his safety belt; on two, he pulled the ripcord on his parachute; on three, he felt the chute take up the slack on his harness. Before he could count to four, he slammed into the water. Martin had bailed out at or about 3,000ft. His parachute had opened but ripped under strain, so instead of floating gently down, he plummeted toward the lagoon..." I was about 300 yards off the beach in a reef-encircled lagoon near the airstrip," he recalled. Japanese soldiers were clearly visible on the beach, cheering the destruction of his plane. What was left of the Avenger had crashed into the water nearby and was burning with an intense heat. Parts of the tail were still splashing into the lagoon. No other parachutes were in sight. Neither Williams nor Hargrove had managed to get out" (Hallas 2019:70-71).	

440613	TBM-1C	25288	VT-16	USS LEXINGTON (CV-16)	SAIPAN	CDR ROBERT HENRY ISELY	M	"Isely's plane was leading with two others behind when his Avenger was hit by anti-aircraft fire at about 4,000 feet. The aircraft burst into flames and exploded at the southern end of the airfield. Neither Isley nor his two crewmen-Lt. (j.g.) Paul Dana and Airman 1st Class J.E. Carey- had time to get out" (Hallas 2019:72).	(Hallas 2019:72)
440613	TBF-1C	24423	VT-16	USS LEXINGTON (CV-16)	SAIPAN	LTJG FRANK M. DELGADO	M	"On June 13, 1944, a TBF1-C Avenger (Bureau Number 25288), with a crew of three, took off from the USS Lexington for a strike against Japanese forces on Saipan in preparation for the U.S. invasion of the island. During the mission, this Avenger was hit by antiaircraft fire and crashed into the sea. Three parachutes were seen to open. The first crewman went down on land, south of Aslito airfield. The second landed about 100 yards off the beach in shallow water, and the pilot a few hundred yards farther south. Machine gunners along the beach strafed the pilot as he descended and collapsed his parachute when he was still about 400 feet in the air. None of the three men was seen again" (DPAA 2023).	https://dpaa-mil.sites.crmforce.mil/dpaaProfile?id=a0Jt000001nzTSBEA2
440614 NONE									
440615	F6F-3	40308	VF-10	USS ENTERPRISE (CV-6)	SAIPAN	LTJG KARL W. KIRCHWEY	M	"AA-40MM, Engine, cockpit" (Fold3 2023).	https://www.fold3.com/image/301618847/report-of-air-

									operations-against-the-marianas-islands-611-2944-including-a-a-actions-on-615-1944-and
440615	FM-2	16200	VC-4	USS WHITE PLAINS (CVE-66)	SAIPAN	LTJG SOLON N BALES	S		
440615	SBD-5	28371	VB-16	USS LEXINGTON (CV-16)	SAIPAN	LT C.T. SCHRADER	S	"…lost one, pilot and crewman recovered." (Fold3 2023)?	https://www.fold3.com/image/277722139/war-diary-61-3044-action-report-p-21-35-page-9-us-world-war-ii-war-diaries-1941-1945
440615	SBD-5	54384	VB-16	USS LEXINGTON (CV-16)	SAIPAN	LTJG D.R. GILLESPIE	S	"…lost one, pilot and crewman recovered." (Fold3 2023)?	https://www.fold3.com/image/277722139/war-diary-61-3044-action-report-p-21-35-page-9-us-world-war-ii-war-diaries-1941-1945
440615	TBF-1C	48121	VC-65	USS MIDWAY (CVE-63)	SAIPAN				
440616	FM-2	16218	VC-4	USS WHITE PLAINS (CVE-66)	SAIPAN	LT E. STRANGLER	S	"At 1058 FM-2 No. 16218, crashed into water, distanced 2000 yards, and sank. Pilot recovered uninjured" (Fold3 2023).	https://www.fold3.com/image/280114163/war-diary-61-3044-page-6-us-

									world-war-ii-war-diaries-1941-1945
440616	SBD-5	10934	VB-16	USS LEXINGTON (CV-16)	SAIPAN	LT B.T. MENNIS	S	"…one SBD crash landed on Bunker Hill and was jettisoned" (Fold3 2023).	https://www.fold3.com/image/277722142/war-diary-61-3044-action-report-p-21-35-page-10-us-world-war-ii-war-diaries-1941-1945
440616	TBM-1C	45556	VT-16	USS LEXINGTON (CV-16)	SAIPAN	LTJG NEWBOLD R. LANDON	M	"…died when his torpedo plane exploded after a direct hit by a Japanese anti-aircraft shell" (Fold3 2023).	https://www.fold3.com/image/277722139/war-diary-61-3044-action-report-p-21-35-page-9-us-world-war-ii-war-diaries-1941-1945
440617	FM-2	16858	VC-68	USS FANSHAW BAY (CVE-70)	SAIPAN	LTJG JOSEPH W. OBERLIN	M	"Lt. (j.g.) Joseph W. Oberlin, USNR, AOM2c D. Albert Yoakum, USNR, and ARM2c George L. Keopp, USNR of VC-68, launched in a TBM-1C (BuNo 16858). The Avenger cleared the catapult but climbed rapidly until it stalled and spun to port, and crashed into the sea off the port bow, where it sank. Shortly after it sank, a violent explosion erupted from the area, most likely because a depth charge detonated, killing the pilot and his two-man crew" (Naval History and Heritage Command 2023).	https://www.history.navy.mil/content/history/nhhc/research/histories/ship-histories/danfs/f/fanshaw-bay.html

440617	FM-2	16224	VC-3	USS KALININ BAY (CVE-68)	SAIPAN			"Lt. Joseph W. Murphy, USNR, splashed into the swells but Cassin Young rescued the pilot. Lt. (j.g.) Leona R. Porterfield, USNR, also hit the water but White Plains lowered a boat that retrieved him, and Murphy and Porterfield returned to the ship on the 25th" (Naval History and Heritage Command 2023).	https://www.history.navy.mil/content/history/nhhc/research/histories/ship-histories/danfs/k/kalinin-bay.html
440617	FM-2	16123	VC-3	USS KALININ BAY (CVE-68)	SAIPAN			"Lt. Joseph W. Murphy, USNR, splashed into the swells but Cassin Young rescued the pilot. Lt. (j.g.) Leona R. Porterfield, USNR, also hit the water but White Plains lowered a boat that retrieved him, and Murphy and Porterfield returned to the ship on the 25th" (Naval History and Heritage Command 2023).	https://www.history.navy.mil/content/history/nhhc/research/histories/ship-histories/danfs/k/kalinin-bay.html
440617	FM-2	16785	VC-3	USS KALININ BAY (CVE-68)	SAIPAN	ENS JAMES T CUZZORT		"The Japanese shot down Ens. James T. Cuzzort, USNR, one of her youngest pilots, in an FM-2 (BuNo 16785), and he was declared missing. Initially unbeknownst to his grieving shipmates, however, Cuzzort ditched his plane in the "drink" in the very midst of the battle and hastily clambered out of the sinking Wildcat and into his small life raft. The man lacked a light with which to signal nearby ships and entered the raft wet and shivered from the cold. He splashed into the water on the windward side of Saipan, still mostly held by the Japanese, and used his parachute as a sea anchor to prevent him from drifting into the beach and likely capture—or execution. Cuzzort floated for nearly 17 hours into	https://www.history.navy.mil/content/history/nhhc/research/histories/ship-histories/danfs/k/kalinin-bay.html

								the next day until he finally saw Pocomoke (AV-9) and used his mirror to attract the seaplane tender's attention. A lookout sighted the pilot and dutifully reported his sighting, but the officers standing watch at first surmised that the glint from Cuzzort's mirror originated from the sun's rays on a drifting tin can and nearly decided to pass him up. Nonetheless, they fortuitously agreed to lay to and spotted and picked the man up and placed him ashore in the U.S.-held portion of the blood-soaked island. The VC-3 commander flew over, retrieved the pilot, and returned him to the ship on the 29th" (Naval History and Heritage Command 2023).	
440617	TBM-1C	16710	VC-68	USS FANSHAW BAY (CVE-70)	SAIPAN	ENS LLOYD F WOODHOUSE	M	"Three VC-68 *Wildcat*s (BuNos 16710 and 46858), and one flown by Lt. Daniel H. Stinemetz (BuNo 45446), crashed during the ensuing turmoil or in battle against the Japanese, but nearby destroyers rescued the shaken men from their life rafts." (Naval History and Heritage Command 2023)	https://www.history.navy.mil/content/history/nhhc/research/histories/ship-histories/danfs/f/fanshaw-bay.html
440617	TBM-1C	45446	VC-68	USS FANSHAW BAY (CVE-70)	SAIPAN	LT STIENMETZ	S	"Later that day, a TBM-1C (BuNo 45446) attempted a landing but crashed ahead of the ship. The plane guard rescued pilot and gunner, but the radioman sank with the aircraft" (Naval History and Heritage Command 2023).	https://www.history.navy.mil/content/history/nhhc/research/histories/ship-histories/danfs/f/fanshaw-bay.html

440617	TBM-1C	25124	VT-51	USS SAN JACINTO (CVL-30)	SAIPAN				
440617	TBM-1C	25540	VC-4	USS WHITE PLAINS (CVE-66)	SAIPAN	LTCDR ROBERT C EVINS		"…at 2105 Squadron Commander R.C. Evins Lieut. Cmdr. U.S. Navy reported his vision obscured an oil leak and landed or crashed into the sea. He is listed as missing" (Fold3 2023).	https://www.fold3.com/image/280114164/war-diary-61-3044-page-7-us-world-war-ii-war-diaries-1941-1945
440618	FM-2	16548	VC-33	USS CORAL SEA (CVE-57)	SAIPAN	LT EUGENE BRADSHAW	D	"Lt.(j.g.) E. Bradshaw, USNR, while landing in VF-40, crashed into the barrier, capsized, and died later as a result of injuries received. Lt.(j.g.) Bradshaw was returning from his second emergency VF scramble for the day" (Fold3 2023).	https://www.fold3.com/image/276916259/act-rep-of-ops-during-assault-occupation-of-saipan-is-marianas-614-2144-page-8-us-world-war-ii-war-d
440618	FM-2	16257	VC-33	USS CORAL SEA (CVE-57)	SAIPAN				
440618	FM-2	16441	VC-41	USS CORREGIDOR (CVE-58)	SAIPAN	LTJG GUZZINS	S		
440618	FM-2	16541	VC-41	USS CORREGIDOR (CVE-58)	SAIPAN	ENS BILLY FRANKS HUDSON	M	"Ensign Billy Franks Hudson, A-V(N), U.S. Naval Reserve (315063)- Missing in Action. This officer was flying an FM-2, Bureau Number 16541, Easy 98130. He disappeared during the CAP flight at about 1000 on June 18, 1944, in the vicinity of Tinian Island. While flying wingman in the formation at	https://www.fold3.com/image/277003066/act-rep-of-ops-610-2844-marianas-operation-page-11-us-world-war-ii-war-diaries-1941-

								approximately 8,000ft, Hudson suddenly turned to the left and disappeared into a cloud while on level flight. There was no indication of engine trouble or failure. He was in communication with the remainder of the flight at the time of his disappearance. No visual contact was made with enemy aircraft in the vicinity during this period" (Fold3 2023).	1945?terms=hudson%2Cuss%2Ccorregidor
440618	TBM-1C	45552	VT-25	USS COWPENS (CVL-25)	SAIPAN	ENS E.C. BELL	S	"Bur ser 45552 pilot Ens. E.C. Bell, (301169), A-V(N), USNR crashed over the side on the port side in landing. Pilot and all crew were rescued uninjured by Spence" (Fold3 2023).	https://www.fold3.com/image/277716725/war-diary-61-3044-page-11-us-world-war-ii-war-diaries-1941-1945
440619	PBM-3D	48173	VP-16		SAIPAN	ENS H.C. CULBRETH	S	"At 1130 K, on 19 June 1944, aviation fuel barge #2, of the USS POCOMOKE was sent to refuel subject aircraft which was moored at buoy located four miles off shore in the open roadstead, off Tanapag Harbor, Saipan. The method of refueling at that time was for the Browser boat to tie alongside of the plane to be refueled. In attempting to do this, the Bowser boat coxswain became convinced it would be advisable to pull away from the plane because the sea was too rough. In pulling away, the screw of the Bowser boat became fouled with the mooring pendant of the buoy. While trying to get clear, the stern of the boat struck the plane's side, venting the seams and puncturing the hull from the port bow hatch aft to the port beaching hatch. Men	https://www.vpnavy.org/vp16_mishap.html

								on board the plane attempted to stuff holes with rags, pillows, and steel wool. This was ineffective. An electrical bilge pump (capacity 10 GPM) and hand bilge pump were also utilized. The plane shipped water faster than it could be taken out. Watertight hatches were closed but it was impossible to isolate the damage because the holes were both forward and aft of the only watertight bulkhead in the plane between the bow compartment and forward end of the after bunkroom. Word was sent to the ship and the tender dispatched additional pumps and personnel. The gasoline pumps they brought were of an insufficient capacity to keep up with the leaks. It was impossible to hoist the plane on board the USS POCOMOKE because the only hoisting sling in the area was, at that time, installed on another aircraft that was in a sinking condition due to gunfire and was being towed toward the USS POCOMOKE. A nearby Destroyer passed a line to the sinking plane, but it was too large to be rove through the tail towing eye. By the time a smaller line could be obtained and made ready, the plane was bowed down and sinking rapidly. Plane sank in two minutes after crew abandoned" (VPNAVY 2023).	

440619	OY-1	75159	VMO-4		SAIPAN				
440620	FM-2	16294	VC-33	USS CORAL SEA (CVE-57)	SAIPAN				
440620	TBM-1C	45562	VT-8	USS BUNKER HILL (CV-17)	SAIPAN	LTJG H.A. BUXTON	S	"Lt. (j.g.) Buxton, with five gallons of gas remaining, made a water landing at 2155 ahead of a DD of the Task Force and was immediately picked up with his gunner. His radioman never emerged from the plane and Lt.(jg) Buxton was unable to open the rear compartment door in his efforts to save him" (Fold3 2023).	https://www.fold3.com/image/277725719/rep-of-air-attack-on-jap-task-force-on-62044-west-of-marianas-islands-page-32-us-world-war-ii-war-di
440620	TBM-1C	45516	VT-8	USS BUNKER HILL (CV-17)	SAIPAN	LCDR K.F. MUSICK	S		
440620	TBM-1C	16868	VT-24	USS BELLEAU WOOD (CVL-24)	SAIPAN	ENS W.D. LUTON	S		
440620	TBM-1C	45646	VT-10	USS ENTERPRISE (CV-6)	SAIPAN	LT V.V. EASON	S	"3 VT and 1 VB planes made forced water landings on return from attack, but all pilots and crewmen were rescued" (Fold3 2023).	http://www.cv6.org/ship/logs/action19440606-0017.htm#0615
440620	TBM-1C	25283	VT-24	USS BELLEAU WOOD (CVL-24)	SAIPAN	LTJG GEORGE P. BROWN	M		

440620	TBM-1C	17090	VT-51	USS SAN JACINTO (CVL-30)	SAIPAN	LCDR D.I. MELVIN	S	"The other VT attempted to land but was out in his approach and did not have sufficient fuel for another safe attempt. He landed ahead of and close aboard a DD in the screen of Task Group 58.1 and was picked up. The pilot and crew were uninjured" (Fold3 2023).	https://www.fold3.com/image/279750993/rep-of-ops-against-saipan-tinian-guam-is-marianas-during-the-period-66-3044-page-18-us-world-war-ii-
440620	TBM-1C	25631	VT-8	USS BUNKER HILL (CV-17)	SAIPAN	LTJG GAGNON	S	"Lt.(j.g.) Gagnon, with zero gallons of gas left, at 2150 landed ahead of a destroyer of the Task Force which very considerately and at some danger to himself illuminated the water ahead for his landing. He and his crew were picked up safely within an hour" (Fold3 2023).	https://www.fold3.com/image/277725719/rep-of-air-attack-on-jap-task-force-on-62044-west-of-marianas-islands-page-32-us-world-war-ii-war-di
440620	TBF-1C	47907	VT-8	USS BUNKER HILL (CV-17)	SAIPAN	LTJG PAUL WILSON JR.	M	"Lieutenant Wilson is believed to have crashed into the water or near the base. A plane was seen to crash and explode by this section leader, on whom Wilson had been lying wing prior to the crash. After that, Lieutenant Wilson's plane was not seen again and Lieutenant Wilson is missing in action" (Fold3 2023).	https://www.fold3.com/image/277725723/rep-of-air-attack-on-jap-task-force-on-62044-west-of-marianas-islands-page-36-us-world-war-ii-war-di
440620	TBF-1C	24468	VT-10	USS ENTERPRISE (CV-6)	SAIPAN	LTJG R.W. CUMMINGS	S	"3 VT and 1 VB planes made forced water landings on return from attack, but all pilots and crewmen were rescued" (CV6 2023).	http://www.cv6.org/ship/logs/action19440606-0017.htm#0615

440620	TBF-1C	47979	VT-14	USS WASP (CV-18)	SAIPAN	ENS C.K. HOFFMAN	S	"Two planes crashed on deck when landing." (Fold3 2023)?	https://www.fold3.com/image/277710911/act-rep-of-first-phase-of-marianas-op-act-against-jap-surface-forces-during-66-2744-page-22-us-world
440620	TBF-1C	47828	VT-14	USS WASP (CV-18)	SAIPAN	LT W.T. WILLIAMS	S	"Two planes crashed on deck when landing." (Fold3 2023)?	https://www.fold3.com/image/277710911/act-rep-of-first-phase-of-marianas-op-act-against-jap-surface-forces-during-66-2744-page-22-us-world
440620	TBF-1C	24478	VT-8	USS BUNKER HILL (CV-17)	SAIPAN	LTJG WILLIS FOLKEDAHL	M	"Lt.(j.g.) Folkedahl is known to have returned within 100 miles of the Task Force. In company with Lt.(jg) Buxton and Lt.(jg) Phillips. He was last seen at approximately 1945 and when he was climbing. It is believed that he bailed out or made a water landing, but at the present date, he and his crew are unreported" (Fold3 2023).	https://www.fold3.com/image/277725720/rep-of-air-attack-on-jap-task-force-on-62044-west-of-marianas-islands-page-33-us-world-war-ii-war-di
440620	TBF-1C	47826	VT-10	USS ENTERPRISE (CV-6)	SAIPAN	LT C.B. COLLINS	S	"3 VT and 1 VB planes made forced water landings on return from attack, but all pilots and crewmen were rescued" (CV6 2023).	http://www.cv6.org/ship/logs/action19440606-0017.htm#0615

440621	SB2C-1C	01044	VB-15	USS ESSEX (CV-9)	SAIPAN	ENS WILLIAM FRANCIS NOLTE	D	"Ensign William Francis Nolte, 23, was killed in action June 20, in the Central Pacific, by antiaircraft fire while diving on enemy gun installations" (Newspapers 2023).	https://www.newspapers.com/image/98150586/?terms=william%20francis%20nolte&match=1
440622	TBM-1C	45558	VT-32	USS LANGLEY (CVL-27)	SAIPAN			"VT-4, bureau No. 45558, made emergency water landing 21 miles bearing 040 true from Langley. Pilot and two crew members rescued uninjured by USS Brown. Plane sank. Cause of forced landing-broken oil line" (Fold3 2023).	https://www.fold3.com/image/277058836/war-diary-61-3044-page-18-us-world-war-ii-war-diaries-1941-1945
440623	TBM-1C	25437	VT-37	USS SANGAMON (CVE-26)	SAIPAN				
440624	OY-1	60498	VMO-4		SAIPAN				
440624	F6F-3	25789	VF-37	USS SANGAMON (CVE-26)	SAIPAN	ENS JESSE E. MCNINCH	S		
440624	F6F-3	41595	VF-32	USS LANGLEY (CVL-27)	SAIPAN			"1829 jettisoned unsalvageable remains of VF-13, bureau No 41595, damaged while taxing after landing when right wheel brake locked and swung into tractor" (Fold3 2023).	https://www.fold3.com/image/277058946/war-diary-61-3044-page-20-us-world-war-ii-war-diaries-1941-1945
440625	PBM-3D	48185	VP-216		SAIPAN	LT V.S. HAGEN	S		

440625	F6F-3	40176	VF-37	USS SANGAMON (CVE-26)	SAIPAN	ENS DEAN R. LEAF	S		
440625	F6F-3	26123	VF-37	USS SANGAMON (CVE-26)	SAIPAN	ENS L.J. EIGNER	S		
440626 NONE									
440627	PBM-3D	48208	VP-16	SAIPAN	SAIPAN	LT DANIEL T. FELIX	S	"…the port engine began to vibrate and developed a considerable oil leak. The automatic propeller speed governor failed at the same time, and the manual control of RPM was also lost. All switches, leads and circuit breakers within the plane pertaining to the propeller pitch control system, were checked and found in good order and proper position. On single engine with a windmilling propeller, pilot increased starboard engine manifold pressure to 38.5", rpm 2400. Bombs and bomb-bay tanks were jettisoned at this time. Air speed was reduced to 90-95 knots and plane continued to lose altitude at the rate of 200-ft per minute. At 0924, the necessity for an open sea landing was clear to the pilot, who notified his base. A full stall landing into the wind was made with an airspeed of 64 knots. The plane landed tail first, and the bow hit at wave which bounced the aircraft approximately 50-ft into the air. The port wing dropped and could not be raised due to the bad engine on that side, and	https://www.vpnavy.org/vp16_mishap.html

								the slow air speed. The plane on the port wing was damaged as listed by landing. The crew left the plane in life rafts, the pilot leaving by walking off the starboard wing. The plane sank less than 90 seconds after landing. All hands were rescued at 1615 K of the same day by the USS BALLARD after another VP-16 plane had sighted the rafts" (VPNAVY 2023).	
440628 NONE									
440629	TBM-1C	16925	VC-68	USS FANSHAW BAY (CVE-70)	SAIPAN	LT PIERCE DAVID MOONEY	D	"The battered ship came about and sailed for Pearl Harbor and battle damage repairs. Flight operations, with their attendant hazards, continued; Lt. Pierce D. Mooney, USNR, died when the Avenger (BuNo 16925) he was piloting from the carrier crashed on 29 June" (Naval History and Heritage Command 2023).	https://www.history.navy.mil/content/history/nhhc/research/histories/ship-histories/danfs/f/fanshaw-bay.html
440629	FM-2	16767	VC-3	USS KALININ BAY (CVE-68)	SAIPAN	LT R. ANDERSON	S		
440630	TBM-1C	16794	VC-65	USS MIDWAY (CVE-63)	SAIPAN	ENS T.F. FRANCO	S		
440701 NONE									
440702	TBM-1C	25110	VC-65	USS MIDWAY (CVE-63)	SAIPAN	LT C.W. SCHUNKE			

440703	TBM-1C	45694	VC-4	USS WHITE PLAINS (CVE-66)	SAIPAN	LT THOMAS LUPO	S		
440704 NONE									
440705	FM-2	46953	VC-3	USS KALININ BAY (CVE-68)	SAIPAN				
440705	SOC-1	9984	VCS-4	USS LOUISVILLE (CA-28)	SAIPAN			"1453 Spotting plane, having been hit by enemy shore-based anti-aircraft, capsized upon landing. Pilot and gunner recovered. Plane sank" (Fold3 2023).	https://www.fold3.com/image/279764323/report-of-operations-in-support-of-occupation-of-saipan-and-tinian-islands-marianas-june-and-july-19
440706 NONE									
440707 NONE									
440708 NONE									
440709	TBF-1C	24276	VC-4	USS WHITE PLAINS (CVE-66)	SAIPAN				
Saipan US Aircraft Losses May 29, 1944 Reconnaissance Mission									

440529	B-24J-50-CO	42-73499	431 BS	Eniwetok	SAIPAN	CAPTAIN LOREN ARTHUR STODDARD		"Between 12:10-12:30, roughly 25 miles from Saipan, this B-24 was intercepted by 8-10 Zero that hit the no 1 and no 2 engines, causing them to smoke then catch fire in the engines, bomb bay and wing and communication with the rear of the plane was cut off. This fire was put out by using extinguishers and diving, but the third time it caught fire the pilots decided to ditch. Two of the crew bailed out, and the B-24 managed to ditch at roughly Lat. 14° 42' N, Long. 146° 57' E. The B-24 stayed afloat for roughly 30 seconds, and the fighters strafed the bomber and the crew in the water" (Pacific Wrecks 2023).	https://pacificwrecks.com/aircraft/b-24/42-73499.html
Saipan US Aircraft Losses February 22, 1944 Raid									
440222	TBM-1C	25186	VT-9	USS ESSEX (CV-9)	SAIPAN	LTJG CLARK RUSHTON WILLIAMS	M		
440222	F6F-3N	08945	VF(N)-76	USS BUNKER HILL (CV-17)	SAIPAN	ENS ROBERT WILLIAM. BICE	M	"Ens. Robert W. Bice, a pilot with VF(N)-76, made four strafing runs on a Japanese airfield but became separated from the other members of his squadron. All returned to *Bunker Hill* except for Bice and Ens. Jack R. Bertie. Despite wounds in his left arm and leg, Bertie engaged in a dogfight with enemy fighters over Tinian and claimed to shoot down three Mitsubishi A6M Type 0 carrier fighters (*Zeros*). In pain the entire way back to the carriers, he managed to land on board *Essex*. He also related a story about seeing Ens. Bice abreast of	https://www.history.navy.mil/research/histories/ship-histories/danfs/b/bunker-hill-i.html

								him during the last strafing run. Bertie then recalled he was "suddenly in the middle of a number of *Zeros*" and stated he believed Bice was shot down by anti-aircraft fire. The battle marked Bice's first and last mission" (Naval History and Heritage Command 2023).	
440222	F6F-3	04908	VF-5	USS YORKTOWN (CV-10)	SAIPAN	LTJG ARTHUR F DAVIS	M	"On February 22, 1944, took off from USS Saratoga as the wingman for F6F Hellcat 40671 piloted by McVay on a fighter sweep over Saipan. Both McVay and his wingman were last seen entering clouds at the start of a strafing run and failed to return from the mission. Possibly, both collided or were shot down" (DPAA 2023).	https://dpaa-mil.sites.crmforce.mil/dpaaProfile?id=a0Jt000001nzVr0EAE
440222	F6F-3	40671	VF-5	USS YORKTOWN (CV-10)	SAIPAN	LT WOODIE LACKLAND MCVAY	M-found 2009	"On February 22, 1944, took off from USS Saratoga as the wingman for F6F Hellcat 40671 piloted by McVay on a fighter sweep over Saipan. Both McVay and his wingman were last seen entering clouds at the start of a strafing run and failed to return from the mission. Possibly, both collided or were shot down" (DPAA 2023).	https://dpaa-mil.sites.crmforce.mil/dpaaProfile?id=a0Jt000001nzVr0EAE

APPENDIX B: FREEDOM OF INFORMATION ACT REQUEST - DON-NAVY-2022-008745

DEPARTMENT OF THE NAVY
NAVAL RESEARCH LABORATORY
4555 OVERLOOK AVE SW
WASHINGTON DC 20375-5320

IN REPLY REFER TO
5720
Ser 1008.11/071
21 Nov 2022

djschaefer93@gmail.com
Daniel Schaefer
Mr. Daniel Schaefer
East Carolina University
709 Johnston St Apt C
Greenville, NC 27858

Subject: FREEDOM OF INFORMATION ACT CASE DON-NAVY-2022-004972/ NRL-FOIA-22-008

Dear Mr. Schaefer:

Thank you for your Freedom of Information Act request dated 25-Feb-22 and received on 25-Feb-22 in which you requested:

> *"...I am requesting access to the U.S. Naval Research Laboratory May 1945 "Laboratory tests of Japanese Mark 4 Model 3 radar transmitter and power supply unit" conducted by L.L. Bonham and E.M Lonsdale. I request that a copy of the following documents be provided to me: Radar transmitters- Tests- Japan 2. Mark 4 Model 3 (Radar) 3. NRL R 2545 In order to help to determine my status to assess fees, you should know that I am affiliated with an educational or noncommercial scientific institution, and this request is made for a scholarly or scientific purpose and not for a commercial use."*

Due to the current COVID-19 pandemic situation, and pursuant to guidance received from the Office of Management and Budget, the Naval Research Laboratory, Freedom of Information Act office has implemented maximum telework flexibilities to protect its employees and their communities.

During this time, personnel will have limited access to requests mailed to FOIA offices in hard copy format via the U.S. Mail or fax machine. There will be a delay in responses to such correspondence as well as the processing of requests and appeals. We encourage you to file your new requests, inquiries, or appeals using email: FOIA@nrl.navy.mil.

We apologize for the delay in responding to your request. NRL FOIA continues its efforts to eliminate the backlog of pending FOIA requests.

The Naval Research Laboratory, FOIA Coordinator, has concluded a comprehensive search for the documents you seek. Our search effort resulted in 23 pages of responsive records being located.

Please be advised pursuant to the Freedom of Information Act, 5 U.S.C. §552 (as amended by Public Law No. 104 231, 110 Stat. 2442), the Naval Research Laboratory has reviewed your request and has determined that the information you are seeking is *granted* under 5 U.S.C. §552 in its entirety. Please find attached 23 of pages of records found responsive to your request.

This concludes the Naval Research Laboratory's response to your FOIA request.

Should you require additional assistance for your FOIA request, you may contact the Naval Research Laboratory's FOIA Coordinator at FOIA@nrl.navy.mil or (202) 768-0585. You may also mail your correspondence to:

Naval Research Laboratory
Attn: Freedom of Information Office, Code 1008.14
4555 Overlook Avenue, SW
Washington DC 20375-0001

You may also contact the DON FOIA Public Liaison, Christopher Julka, at christopher.a.julka@navy.mil, (703)697-0031. Additionally, you may contact the Office of Government Information Services (OGIS) at the National Archives and Records Administration to inquire about the FOIA mediation services they offer. The contact information for OGIS is as follows:

Office of Government Information Services
National Archives and Records Administration
8601 Adelphi Road-OGIS
College Park, Maryland 20740-6001
e-mail at ogis@nara.gov
telephone at 202-741-5770

If you determine that the response to your FOIA request necessitates an appeal, you may initiate your appeal by writing to:

Office of the General Counsel
Department of the Navy
ATTN: FOIA/PA Appeals Office
1000 Navy Pentagon, Room 5A532
Washington, DC 20350-1000

Your appeal must include the designated reference numbers (DON-NAVY-2022-004972/NRL-FOIA-22-031), a copy of your original request, a copy of this letter, your supporting rationale on why the appeal should be granted, and any other information you would like considered in adjudicating your appeal. The appeal must be postmarked no later than ninety (90) calendar days from the date on this letter.

BAXTER.MILDRED.RENEE.1610971381 Digitally signed by BAXTER.MILDRED.RENEE.1610971381 Date: 2022.11.21 17:58:31 -05'00'

FOIA Coordinator
Naval Research Laboratory