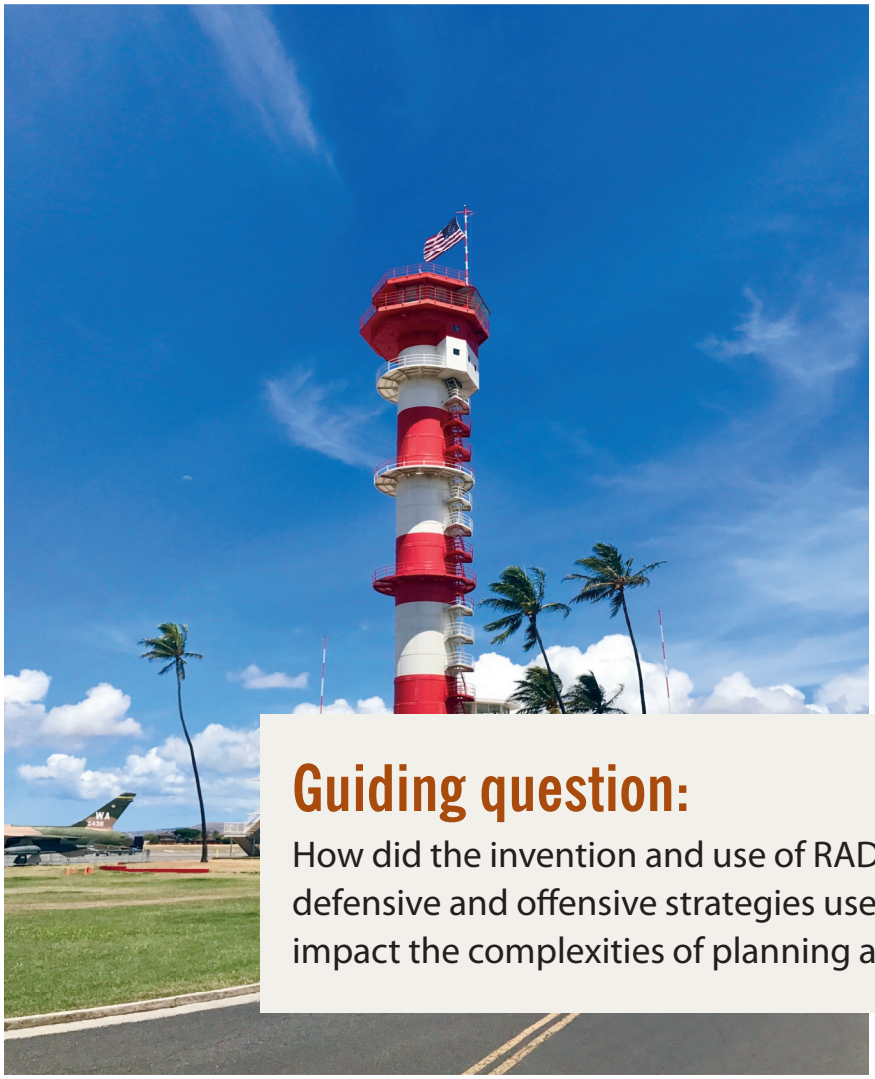
UNDERSTANDING SACRIFICE

Activity: RADAR: Innovating Naval Warfare



Guiding question:

How did the invention and use of RADAR technology alter the defensive and offensive strategies used in the Pacific Theater and impact the complexities of planning and plotting attacks in war?

DEVELOPED BY WHITNEY JOYNER

Grade Level(s):	**6-8, 9-12**
Subject(s):	**Social Studies, Geography, Science, Mathematics**
Cemetery Connection:	**West Coast Memorial**
Fallen Hero Connection:	**Quartermaster Second Class Edgar Blannam Atkinson**

NHD NATIONAL HISTORY DAY

ROY ROSENZWEIG Center FOR History AND New Media

Overview

Using interactive technology from the American Battle Monuments Commission, maps, and primary and secondary source analysis, students will determine how the invention of RADAR impacted the war in the Pacific while plotting an attack on an enemy convoy.

Historical Context

What began as a laboratory experiment developed into a new military technology that would serve as a powerful offensive and defensive weapon for the Allies throughout World War II. RADAR (RAdio Detection And Ranging) is a system capable of detecting objects using radio waves to determine range, angle, and location. RADAR was utilized throughout the war to locate air, ground, and sea targets. RADAR did not possess a long enough range to be able to detect ships in the vast ocean of the Pacific. LORAN (LOng RAnge Navigation) was created as a solution to this problem, and also made it possible to use it without breaking radio silence. Military personnel, scientists, engineers, fabricators, technicians, and radio operators all played an integral role in building, deploying, and maintaining the use of RADAR systems throughout the Pacific Theater.

"The invention of RADAR and sonar technologies was a pivotal turning point in the defensive and offensive efforts of the Allies in World War II. My interest in this topic began with researching Quartermaster Second Class Edgar Blannam Atkinson. Placing students in the simulation of a plotting room gives them the opportunity to experience a piece of the quick and complex decision making those in the Combat Information Center were faced with at sea. This new technology impacted both military and civilian life and inspired future innovation in navigation."
—Whitney Joyner

Joyner teaches at Northeast Middle School in Clarksville, TN.

Objectives

At the conclusion of this lesson, students will be able to

- Analyze primary and secondary sources to learn about the role that RADAR played in World War II;
- Describe the role the invention of RADAR played in the Pacific Theater during World War II;
- Evaluate the importance of RADAR use for both offensive and defensive efforts at sea and in the air; and
- Calculate time, distance, and speed while plotting an enemy convoy attack, giving students a better understanding of the complexities of plotting attacks in war, how RADAR works, and the science, math, and technology involved in war.

Standards Connections

Connections to Common Core

CCSS.ELA-LITERACY.RH.6-8.9 Analyze the relationship between a primary and secondary source on the same topic.

CCSS.ELA-LITERACY.RH.6-8.2 Determine the central ideas or information of a primary or secondary source; provide an accurate summary of the source distinct from prior knowledge or opinions.

CCSS.ELA-LITERACY.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

CCSS.MATH.CONTENT.8.EE.C.8.C Solve real-world and mathematical problems leading to two linear equations in two variables.

Connections to C3 Framework

D2.Geo.3.6-8. Use paper based and electronic mapping and graphing techniques to represent and analyze spatial patterns of different environmental and cultural characteristics.

D2.Geo.7.6-8. Explain how changes in transportation and communication technology influence the spatial connections among human settlements and affect the diffusion of ideas and cultural practices.

D2.His.14.6-8. Explain multiple causes and effects of events and developments in the past.

ISTE Standards for Students

5. Computational Thinker Students develop and employ strategies for understanding and solving problems in ways that leverage the power of technological methods to develop and test solutions. Students: a. formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions. b. collect data or identify relevant data sets, use digital tools to analyze them, and represent data in various ways to facilitate problem-solving and decision-making. c. break problems into component parts, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving. d. understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

Documents Used ★ indicates an ABMC source

Primary Sources

Film, *Conquest of the Night*
U.S. Navy, U.S. Marine Corps, and U.S. Coast Guard, 1945
https://www.youtube.com/watch?v=-BiBg2eOT-I

RADAR Plot from Station Opana, Pearl Harbor, Hawaii, 1941
National Archives and Records Administration (2600930)
https://catalog.archives.gov/id/2600930

Secondary Sources

"What If?" Radar Operation on the Day of the Pearl Harbor Attack ★
American Battle Monuments Commission
https://youtu.be/R6SueP3eP3o

Map, *The Far East and the Pacific 1941*
United States Military Academy at West Point
http://www.westpoint.edu/history/SiteAssets/SitePages/World%20War%20II%20Pacific/WWIIAsia01.pdf

Map, *The Invasion of Leyte and the Battle for Leyte Gulf, October 1944*
United States Military Academy at West Point
http://www.westpoint.edu/history/SiteAssets/SitePages/World%20War%20II%20Pacific/ww2%20asia%20map%2029.jpg

Map, *Major Operations of World War Two in the Pacific Theater*
United States Military Academy at West Point
http://www.westpoint.edu/history/SiteAssets/SitePages/World%20War%20II%20Pacific/WorldWarTwoAsiaOverview.pdf

Map, *Major Japanese War Objectives and Planned Opening Attacks*
United States Military Academy at West Point
http://www.westpoint.edu/history/SiteAssets/SitePages/World%20War%20II%20Pacific/WWIIAsia04.pdf

World War II: A Visual History ★
American Battle Monuments Commission
https://www.abmc.gov/sites/default/files/interactive/interactive_files/WW2/index.html

Materials

- RADAR Plotting Map
- RADAR Plotting Scenario Teacher's Guide
- Convoy Attack Team Planning Guide
- RADAR in World War II Graphic Organizer
- A Closer Look at RADAR during World War II Handout
- Optional Strategic Value Cards for Plotting Team Activity
- Quick Write Assessment Rubric
- Pencils and erasers for plotting
- Calculators
- Computer with internet and projection capabilities to show video clips

Lesson Preparation

Activity One:

- Pre-arrange students in pairs for the first activity.
- Cue up the *World War II: A Visual History* to the December 1941 Japanese Attack on Pearl Harbor section and ensure both sound and video are in working order.
- Cue up the *"What If?" Radar Operation on the Day of the Pearl Harbor Attack* video and ensure both sound and video are in working order.
- Cue up the *Conquest of the Night* video and ensure both sound and video are in working order.
- Make one copy of the following for each pair of students:
  - RADAR Plot from Station Opana, Pearl Harbor, Hawaii, 1941
  - A Closer Look at RADAR during World War II Handout
  - RADAR in World War II Graphic Organizer

Activity Two:

- Pre-arrange students into groups of three or four students each for the Plotting Team Activity.
- Make one copy each of the following for each group of students:
  - Map, *Major Operations of World War Two in the Pacific Theater*
  - Map, *Major Japanese War Objectives and Planning Opening Attacks*
  - Convoy Attack Team Planning Guide
  - RADAR Plotting Map (make extra copies in case students make mistakes in their plotting)
  - Map, *The Invasion of Leyte and the Battle for Leyte Gulf* (optional)
  - Strategic Value Cards for Plotting Team Activity (optional)
- Make one copy of RADAR Plotting Scenario Teacher's Guide for teacher use.

- Make one copy Quick Write Assessment Rubrics for each student.

Procedure

Activity One: Understanding the Role of RADAR (60 minutes)

- Show students the ABMC *World War II: A Visual History* - Japanese Attack Pearl Harbor video and read the excerpt that accompanies the video.
  - Ask the students, *What emotions and reactions do you think Americans had following the attack on Pearl Harbor?*
- Show students the *"What If?" Radar Operation on the Day of the Pearl Harbor Attack* video filmed at the Pacific Aviation Museum.
  - Ask the students, *Why was the attack a surprise? If the attack on Pearl Harbor happened today, what technology could be used to warn our military and citizens?*
- Distribute copies of the RADAR Plot from Station Opana, Pearl Harbor, Hawaii, 1941 for students to analyze.
  - Ask pairs to analyze the document and respond to the following questions:
    - *What words/dates stand out to you on this document?*
    - *What are the numbers throughout the document?*
    - *Who do you think created this document?*
    - *Why do you think this document was created? What is the significance of this document?*
    - *Summarize this document in two or three sentences.*
  - Discuss student answers to the questions in a whole class discussion.
    - ***Teacher Tip:*** Explain to students that this document is the actual RADAR plot from the detection station at Opana Point in Oahu, Hawaii from the day Pearl Harbor was attacked. This plot was used in a Congressional committee meeting as evidence in the investigation of the attack.
- Move students into pairs and distribute a copy of A Closer Look at RADAR during World War II Handout and RADAR in World War II Graphic Organizer to each pair.
  - Ask each pair to analyze the various ways the invention of RADAR was used in World War II and complete the graphic organizer.
- Show students the Conquest of the Night video.
  - Ask students, *How did the invention and use of RADAR technology alter the outcome of the war in the Pacific?*
  - ***Teacher Tip:*** Use this discussion time to review the graphic organizer pairs completed and discuss the propaganda video.
- Close the lesson by telling students that tomorrow they will have the opportunity to learn the science and math behind RADAR plotting and that they will be working in teams to plot an attack on an enemy convoy.

Activity Two: Attack! (60 minutes)

- Divide students into teams of three students each. These teams will become their "Plotting Teams."
- Give each team one copy of the *Map of Major Japanese War Objectives and Planning Opening Attacks* and one copy of the *Major Operations of World War Two in the Pacific Theater* Map.
- Direct each team to analyze the two maps and answer the following questions for both maps on their own sheet of paper. Following think time, lead a class discussion, comparing and contrasting both maps and student answers.
  - *What area of the world is this map displaying?*
  - *What information is the map presenting?*
  - *From whose perspective is this map being shown?*
- Explain that students will work in their Plotting Teams to plot an attack on an enemy convoy. The teacher will serve as the RADAR, providing the information needed about the distance, time, and speed of the enemy.
- Provide one copy of the Convoy Attack Team Planning Guide and Map for Plotting handouts to each team.
  - ***Teacher Tip:*** Teachers with advanced students may choose to provide each team with a copy of the Map, The Invasion of Leyte, October 1944 and Strategic Value Cards for Plotting Team Activity for students to to use in the plotting activity.
- Follow the step-by-step directions in the RADAR Plotting Scenario Teacher's Guide.
- Debrief at the conclusion of the class using the following questions:
  - *What were some of the problems you encountered while plotting your attack?*
  - *How did you overcome these problems?*
  - *What information was most helpful in planning your attack?*
  - *What path did you choose and what justification/strategic reasoning can you provide for the path you chose?*
  - *In what ways could RADAR be beneficial on the offensive side of war? The defensive side?*
  - *How has RADAR evolved over time and what are we able to do with RADAR technology today?*
  - *What inventions/innovations do you use today that incorporate RADAR technology?*

Assessment (15 minutes)

- Pose the following question to students: *How did the invention and use of RADAR technology alter the outcome of the war in the Pacific?*
- Instruct students to complete a quick write, answering the question, while citing evidence and examples from their work over the course of the last two days.
- The Quick Write Assessment Rubric can be used to score this assessment.

Methods for Extension

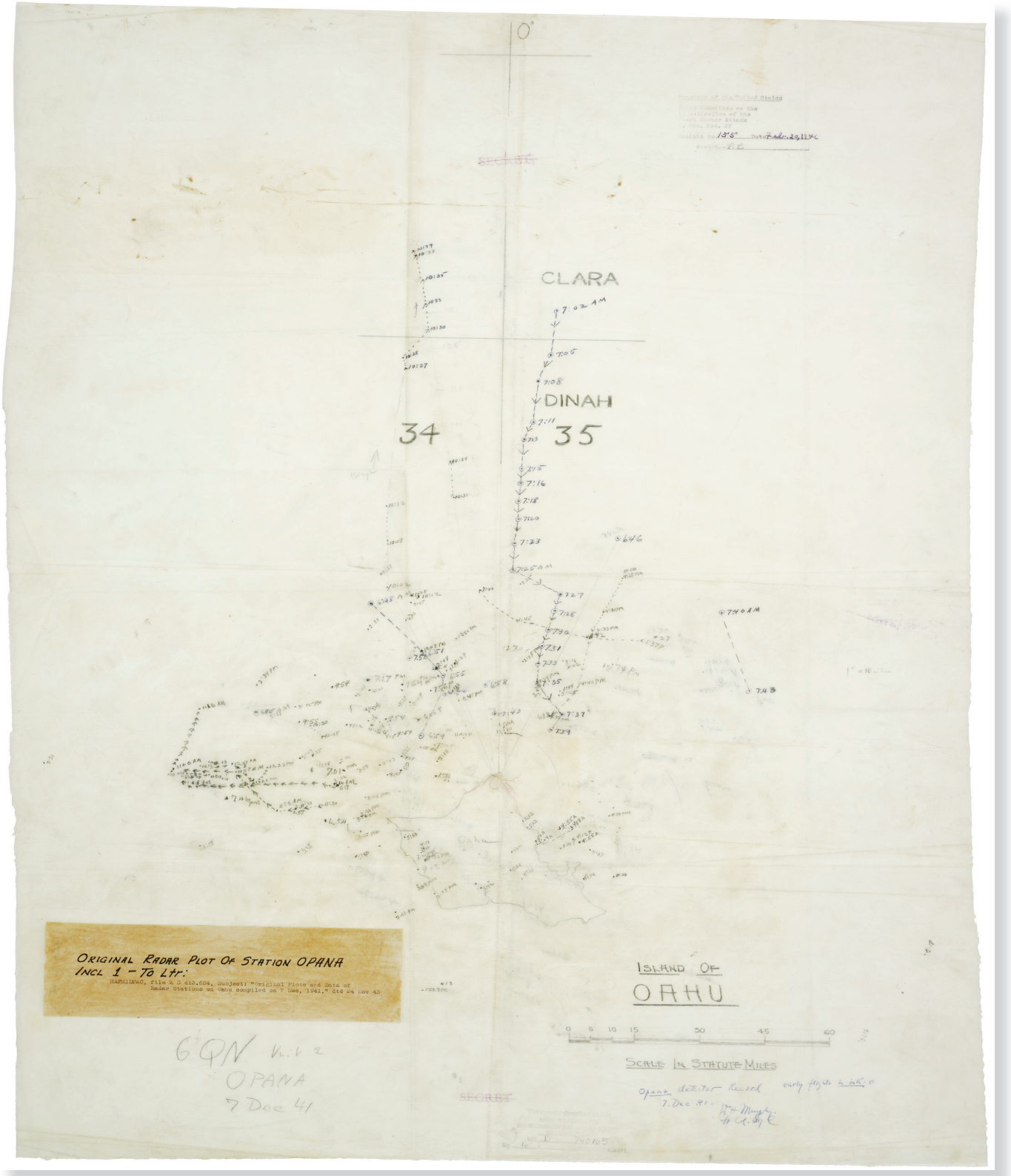
- Students with more interest in the role that RADAR played in World War II can research the role RADAR played in the Battle of Britain. Students can also research the discovery and use of RADAR by the Axis powers.
- The lesson can be adapted for more advanced students by incorporating more advanced calculations into the plotting portion of the lesson. From calculating trajectory and plotting vectors, there are many levels of math that can be incorporated into this activity.
- Teachers can enhance students' interest in the impact of science, mathematics, and technology in World War II by exploring these related lesson plans on ABMCEducation.org:
  - *Flight Plans and Rescues: Using Math to Explore the World War II Strategic Bombing Campaign*
  - *Horror in the Hedgerows: Technology, Tactics, and Teamwork*
  - *The Army Engineers: Challenges at the Anzio Beachhead*
  - *The Math of War: The Numbers Behind Minesweeping in the Mediterranean*
  - *The Calculus of War: Tactics, Technology, and the Battle of the Atlantic*

Adaptations

- Teachers can adapt the project to younger learners or learners with special needs by simplifying the plotting and changing the Maneuverability Board to a basic X, Y axis grid and allowing students to plot basic points.

RADAR Plot from Station Opana, Pearl Harbor, Hawaii, 1941

National Archives and Records Administration (2600930)



A Closer Look at RADAR during World War II

What began as a laboratory experiment developed into a new military technology that would serve as a powerful offensive and defensive weapon for the Allies throughout World War II. RADAR (RAdio Detection And Ranging) is a system capable of detecting objects using radio waves to determine range, angle, and location. RADAR was utilized throughout the war to locate air, ground, and sea targets.

In the Pacific, RADAR did not possess a long enough range to be able to detect ships in such vast oceans. LORAN (LOng RAnge Navigation) was created as a solution to this problem, and also made it possible to use it without breaking radio silence. Military personnel, scientists, engineers, fabricators, technicians, and radio operators all played an integral role in building and deploying the use of RADAR systems throughout the Pacific Theater.

Bombing

Boeing B-17F RADAR bombing through clouds over Bremen, Germany, November 13, 1943. National Museum of the U.S. Air Force.

The development of the bombsight helped to make RADAR a strategic weapon. RADAR allowed for more accurate bombing and precision targeting of military and industrial locations. Because of RADAR, Allied Air Forces were better able to attack targets at night and during inclement weather.

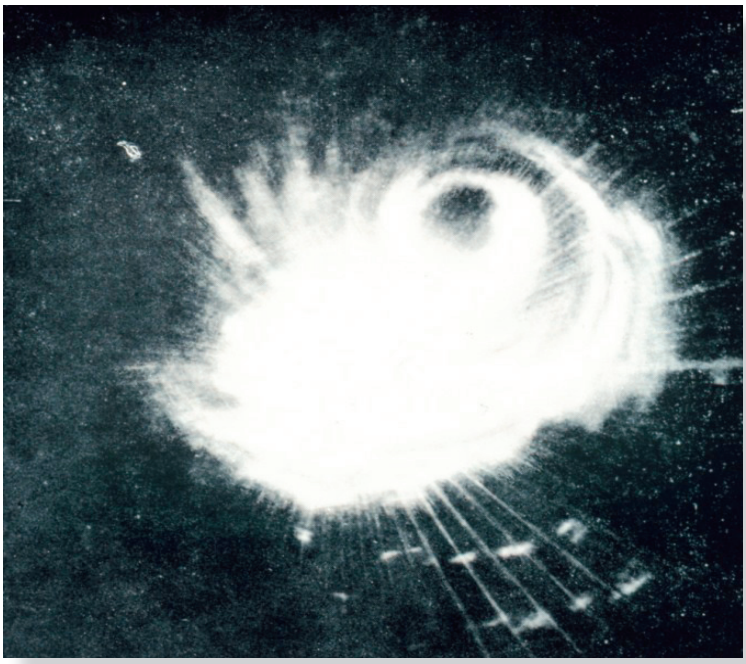
A Closer Look at RADAR during World War II cont.

Chain Home RADAR

The British Royal Air Force (RAF) built Chain Home Early Warning RADAR stations during World War II to detect and track aircraft. Chain Home RADAR provided the RAF with almost 30 minutes of warning time to intercept threats. The system could detect German formations before they could reach the English Channel. British Women's Auxiliary Air Force (WAAF) plotters and duty officers helped to run these stations during the war. Pictured here, women tellers recorded information from the Filter Room and relayed it to plotters, who reproduced it on their map.

The Operations Room at the Royal Air Force Fighter Command's No. 10 Group Headquarters at Rudloe Manor in Wiltshire. This image shows British Women's Auxiliary Air Force (WAAF) plotters and duty officers at work, 1943. Imperial War Museum (CH 11887).

Monitoring Weather

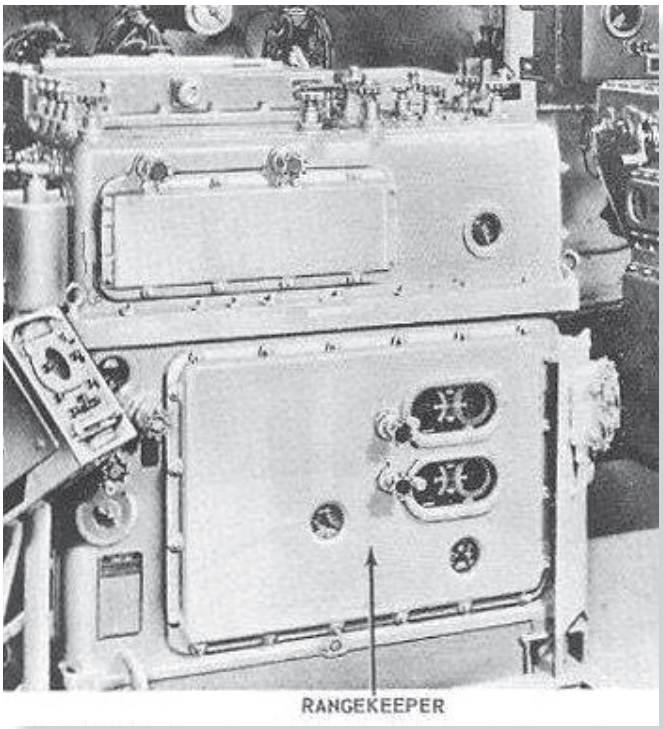


An image of Typhoon Cobra captured by the RADAR of a U.S. Navy ship. The typhoon, located east of the Philippines, was the second tropical storm to be observed using RADAR, December 18, 1944. National Oceanic and Atmospheric Administration Photograph Library.

Military meteorologists used RADAR to track various types of weather, and in particular, storms. Typhoon Cobra was the U.S. Navy's designation for a tropical storm cyclone that struck the U.S. Pacific Fleet in December 1944. Pictured here is the eye structure of the storm as captured on RADAR.

A Closer Look at RADAR during World War II cont.

Fire Control



A Mark 8 fire control RADAR system. U.S. Navy.

RADAR was also used to direct gunfire and used to aim anti-aircraft guns.

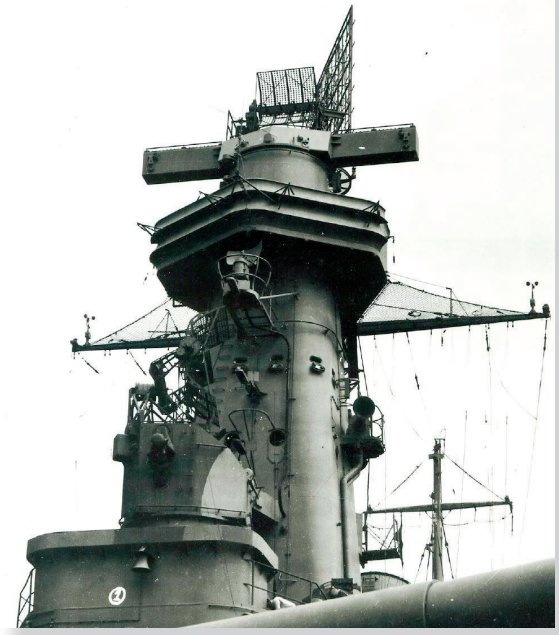
Fire Control RADAR was commonly used by night fighters to locate a precise position of a detected target. This type of RADAR helped guide pilots close enough to a target to see it, aim their guns, and hit it.

The Mark 8 fire control RADAR (shown here) directed large-caliber battleship and cruiser guns. It was also ideal for fire control against surface targets.

Naval Surface Search

The SG Surface Search RADAR was installed on destroyers and larger ships to assist in locating enemy surface ships, coordinating attack by surface vessels, and to aid in navigation.

The SG Surface Search RADAR could detect large ships at a distance of 15 miles and a submarine periscope at five miles, due to its gyro-stabilized mount.



The SG Surface Search RADAR unit on the forward face of the tower on the USS Washington, photographed at the New York Navy Yard on August 18, 1942. U.S. Navy.

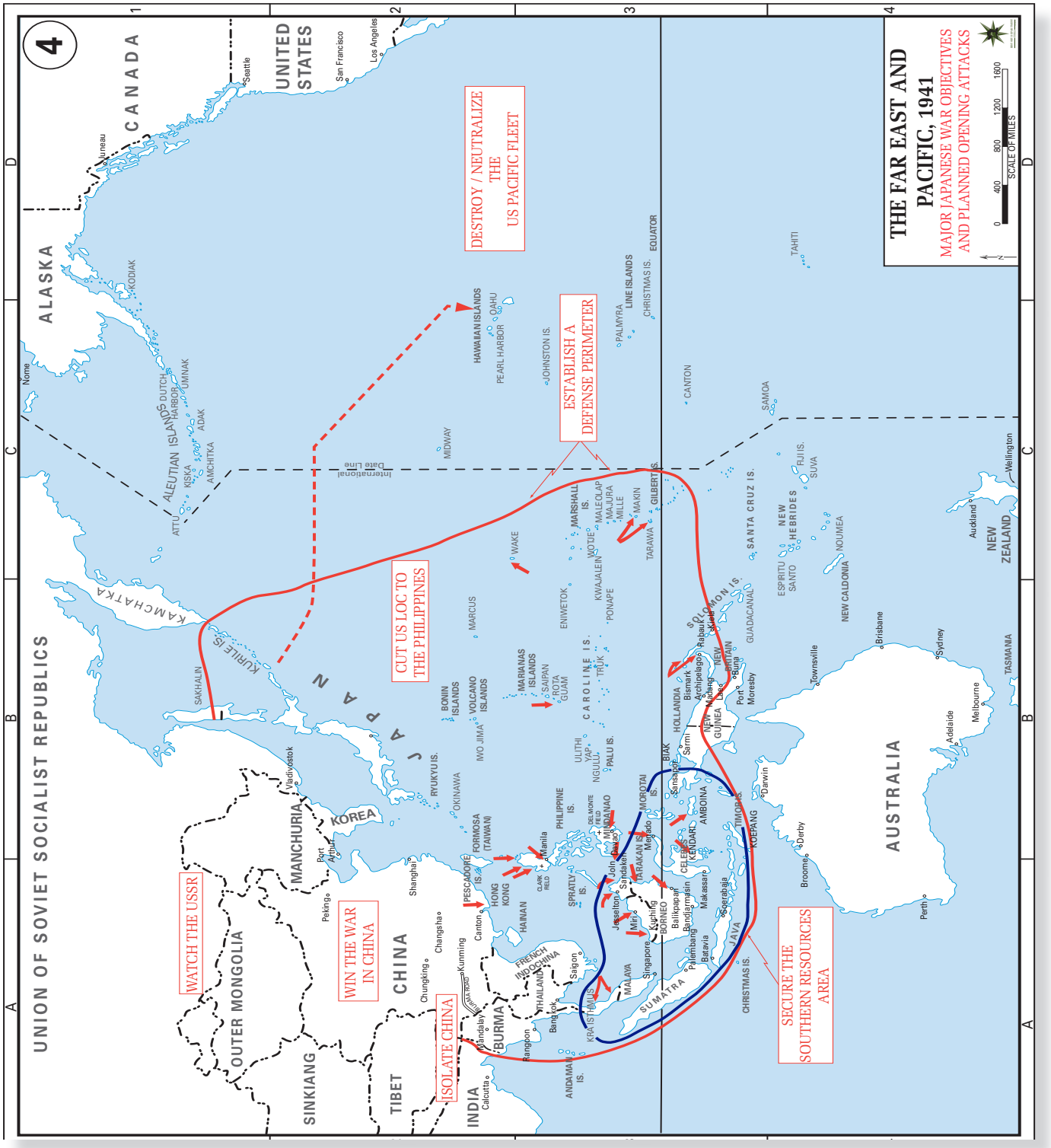
RADAR in World War II Graphic Organizer

Directions: Complete the following chart using the *A Closer Look at RADAR During World War II* handout.

Who used RADAR during World War II?	What did this person or group use RADAR to accomplish?
Synthesis: How did the invention of RADAR impact the outcome of World War II?	

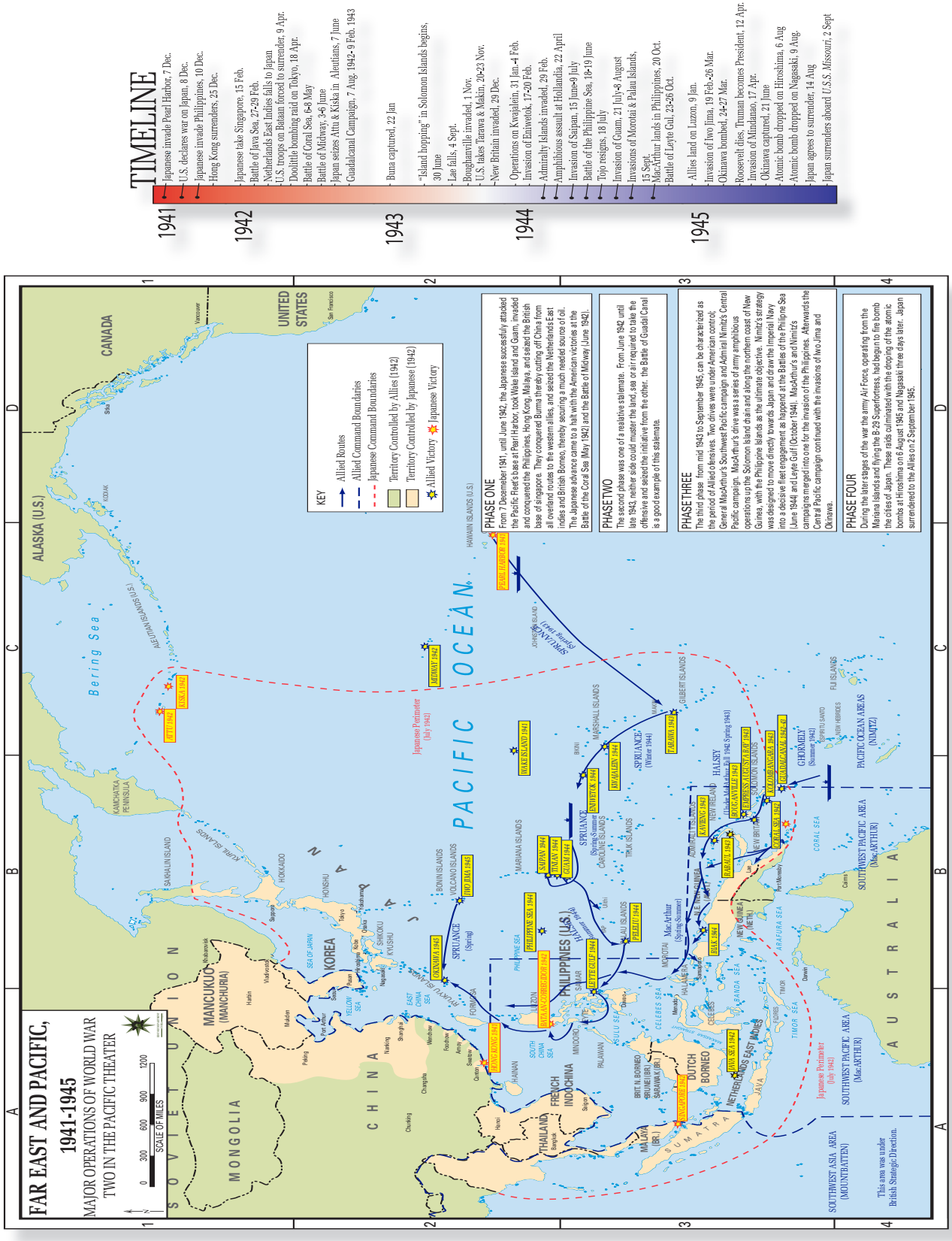
Map, *Major Japanese War Objectives and Planned Opening Attacks*

United States Military Academy at West Point



Map, *Major Operations of World War Two in the Pacific Theater*

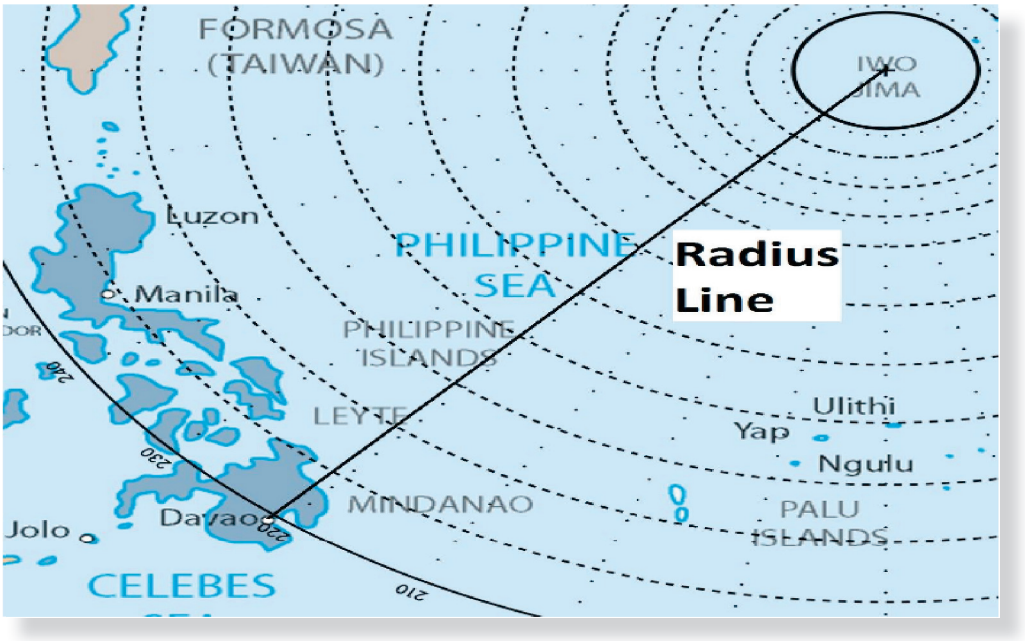
United States Military Academy at West Point



Convoy Attack Team Planning Guide

Step 1: Locating your own convoy. Your convoy is located in the center of the innermost circle on your Maneuvering Board. Please place a star on the location of your own convoy.

Step 2: Based on the provided Plotting Map, you must first determine the size of the region in which you are traveling (the area represented by the concentric circles.) If Iwo Jima is the center of the Maneuvering Board and the city of Davao, Philippines is at the outermost concentric circle of the Maneuvering Board, the radius line, showing the distance between the two points are 1,400 Nautical Miles or 2,575 kilometers.



Using the following formulas, answer the following questions for both nautical miles and kilometers.

1. What is the diameter of the Maneuvering Board (radius x 2)?

Nautical Miles	Kilometers

Convoy Attack Team Planning Guide cont.

2. What is the circumference of the Maneuvering Board (π x diameter)?

Nautical Miles	Kilometers

When dealing with military operations, timing and location are of the utmost importance. Knowing the full area in which you are traveling (and more importantly, where the enemy is traveling) and your RADAR capabilities can be the difference between a sound victory or a bitter defeat.

3. What is the area of the Maneuvering Board (π x radius^2)?

Nautical Miles	Kilometers

Step 3: Your convoy is traveling in a Northwest direction toward the enemy. We will begin by calculating your convoy's speed in knots. The knot is a unit of speed equal to one nautical mile (1.852 km). Your convoy is able to travel at a speed of 28 kph. Calculate the speed in knots (kph/nm) that your convoy is traveling.

Your Convoy's Speed in Knots: _____

Convoy Attack Team Planning Guide cont.

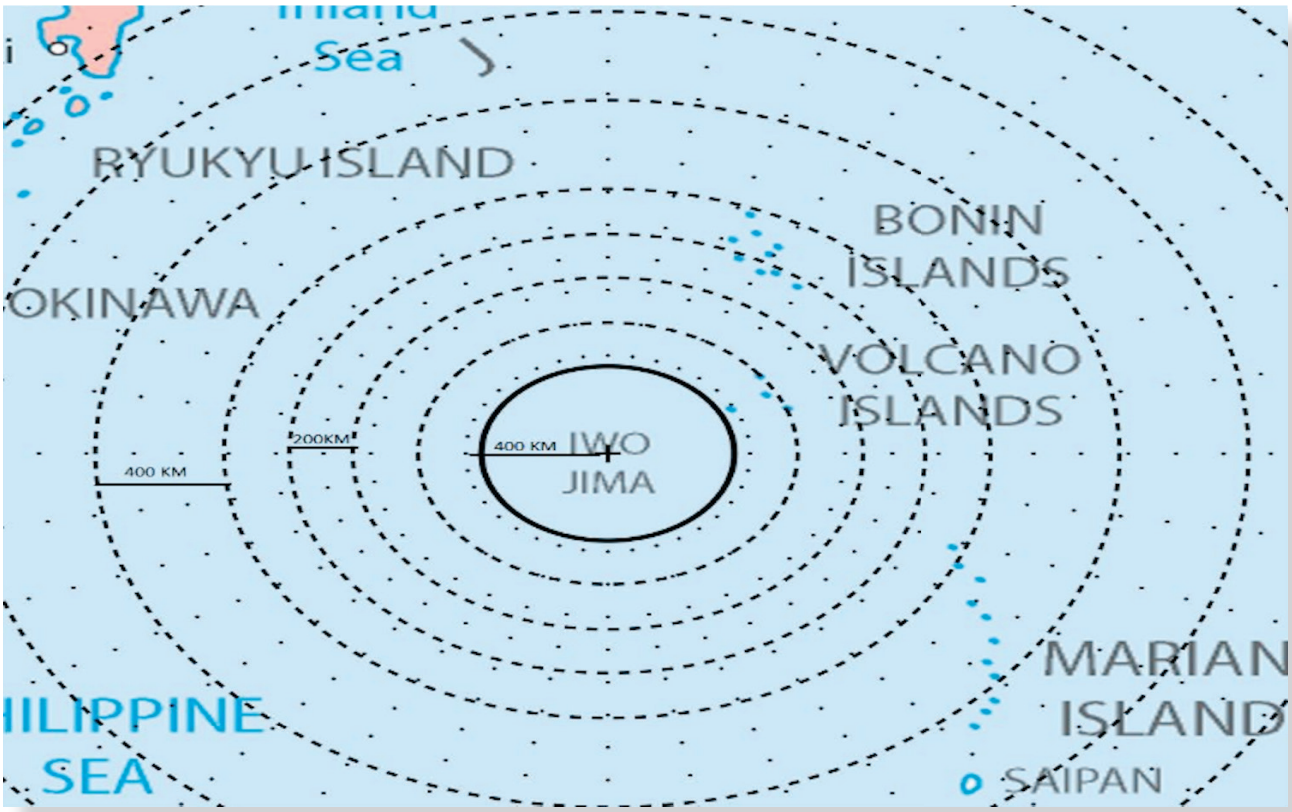
Step 4: The enemy convoy is traveling at a speed of 20 knots. How many kph (knots x 1 NM) is the enemy convoy traveling?

The Enemy Convoy's Speed in kph: _____

Step 5: Plot the following enemy convoys your Plot/Map:

(One large concentric circle represents 400km, one small (inner) circle represents 200 km, Iwo Jima to first concentric circle is 400 km)

1. northwest 320 degrees, 1,200 kilometers from your convoy
2. southeast 150 degrees, 2,000 kilometers from your convoy
3. southwest 245 degrees 3,200 kilometers from your convoy
4. northeast 20 degrees, 500 kilometers from your convoy
5. southeast 225 degrees, 3,200 kilometers from your convoy



Convoy Attack Team Planning Guide cont.

Step 6: If target 4 (from **Step 5** above) is traveling at 20 knots, how long will it take to intercept our convoy (presuming we are stationary at Iwo Jima). The following metrics have been provided to assist with the following question.

Distance = Speed x Time
Time = Distance/Speed
Speed = Distance/Time

Time it Will Take to Intercept our Convoy: _____

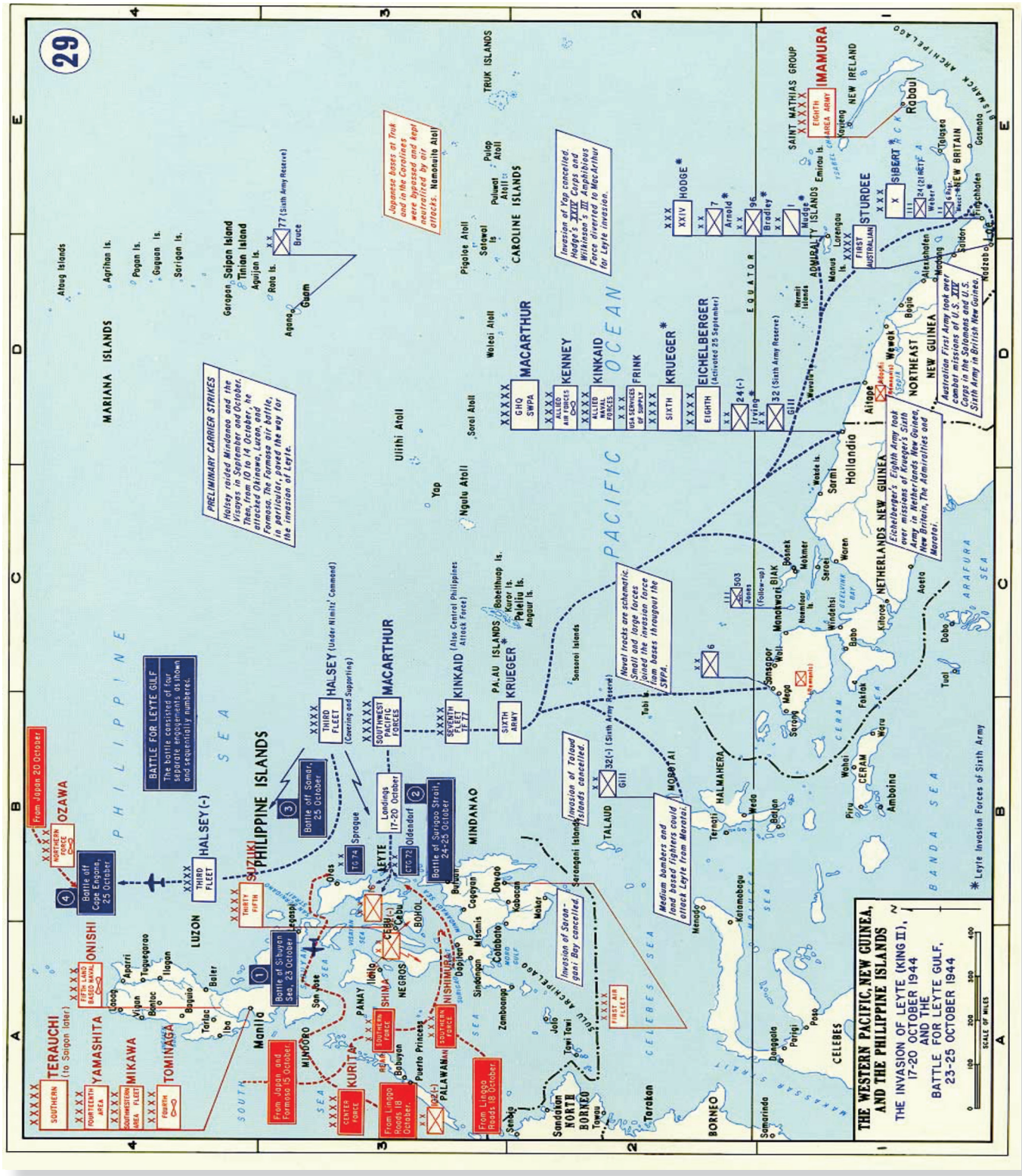
Step 7: In your team, plot your course of attack based on one of the enemy convoys location as seen in Step 5. You must decide how many vessels in your convoy will attack, how fast you will travel, and what path(s) you will take to get there. Please plot out your plan of attack on the map provided. Please write out a justification for your decisions in the space provided.

Justification for Plan of Attack:

Radar Plotting Map

Map, *The Invasion of Leyte and the Battle for Leyte Gulf*, October 1944

United States Military Academy at West Point


THE WESTERN PACIFIC, NEW GUINEA, AND THE PHILIPPINE ISLANDS
THE INVASION OF LEYTE (KING II), 17-20 OCTOBER 1944 AND THE BATTLE FOR LEYTE GULF, 23-25 OCTOBER 1944
PHILIPPINE SEA
PACIFIC OCEAN
SOUTH CHINA SEA
CELEBES SEA
BANDA SEA
ARAFURA SEA
PHILIPPINE ISLANDS
LUZON
MINDANAO
LEYTE
MARIANA ISLANDS
CAROLINE ISLANDS
TRUK ISLANDS
PALAU ISLANDS
BORNEO
CELEBES
NEW GUINEA
NETHERLANDS NEW GUINEA
NEW IRELAND
NEW BRITAIN
BATTLE FOR LEYTE GULF
The battle consisted of four separate engagements as shown and sequentially numbered.
PRELIMINARY CARRIER STRIKES
Halsey raided Mindanao and the Visayas in September and October. He then, from 10 to 14 October, he attacked Okinawa, Luzon, and Formosa. The Formosa air battle, in particular, paved the way for the invasion of Leyte.
Japanese bases on Truk and in the Carolines were neutralized and kept neutralized by air attacks.
Invasion of Yap cancelled. Hodge's XXIV Corps and Wilkinson's III Amphibious Force diverted to MacArthur for Leyte invasion.
Australian First Army took over combat missions of U.S. XIV Corps in the Solomons and U.S. Sixth Army in British New Guinea.
Eichelberger's Eighth Army took over missions of Krueger's Sixth Army in Netherlands New Guinea, New Britain, the Admiralties and Moratai.
Naval tracks are schematic. Small and large forces joined the invasion force from bases throughout the SWPA.
Invasion of Talaud Islands cancelled.
Medium bombers and land based fighters could attack Leyte from Moratai.
Invasion of Sarangani Bay cancelled.
Leyte Invasion Forces of Sixth Army
SCALE OF MILES
HALSEY (Under Nimitz' Command)
MACARTHUR
KINKAID (Also Central Philippines Attack Force)
KRUEGER
HALSEY (-)
TERAUCHI
YAMASHITA
MIKAWA
TOMINAGA
ONISHI
OZAWA
SUZUKI
KURITA
MACARTHUR
KENNEY
KINKAID
FRINK
KRUEGER
EICHELBERGER
HODGE
STURDEE
IMAMURA
Battle of Sibuyan Sea, 23 October
Battle off Cape Engaño, 25 October
Battle off Samar, 25 October
Battle of Surigao Strait, 24-25 October
Landings (17-20 October)
From Japan 20 October
From Japan and Formosa 15 October
From Lingga Roads 18 October
From Lingga Roads 18 October
Manila
Leyte
Cebu
Mindoro
Palawan
Tacloban
Dulag
Burauen
Dagupan
Lingayen
Aitape
Hollandia
Wewak
Biak
Morotai
Halmahera
Ternate
Tarakan
Samarinda
Balikpapan
Amboina
Kendari
Palau Islands
Yap
Ulithi Atoll
Woleai Atoll
Sorol Atoll
Ngulu Atoll
Guam
Saipan
Tinian
Rota
Agana
Garapan
Truk
Pulap Atoll
Pulusuk Atoll
Satawal Is.
Pigailoi Atoll
Nomonuito Atoll
Saint Mathias Group
Admiralty Islands
Manus
Los Negros
Momote
Lorengau
Emirau Is.
Rabaul
Kavieng
Gasmata
Finschhafen
Lae
Salamaua
Nadzab
Markham Valley
Ramu Valley
Owen Stanley Mts.
Huon Peninsula
Vitiaz Strait
Dampier Strait
Solomon Islands
Bougainville
Rabaul
Kavieng
Truk Islands
Marianas
Carolines
Equator
Arafura Sea
Banda Sea
Celebes Sea
Sulu Archipelago
Mindanao Sea
Visayan Sea
Philippine Sea
South China Sea
Luzon Strait
Bismarck Archipelago
Solomon Sea
Coral Sea
Tasman Sea
Timor Sea
Java Sea
Flores Sea
Molucca Sea
Ceram Sea
Halmahera Sea
Celebes Sea
Sulu Sea
Mindoro Strait
Surigao Strait
Leyte Gulf
Lingayen Gulf
Subic Bay
Manila Bay
Batangas Bay
Tayabas Bay
Lamon Bay
Ragay Gulf
Sibuyan Sea
Visayan Sea
Mindanao Sea
Sulu Archipelago

Strategic Value Cards for Plotting Team Activity

Strategic Value of Leyte

The Leyte operation was a critical battle of the war in the Pacific. Its outcome altered the future course of the war against Japan. Leyte, located in the heart of the Philippine archipelago, became the point where the Southwest Pacific and Central Pacific forces merged in an attempt to take the Philippines out of enemy hands. With Leyte under Allied control, the other islands would be within better striking distance of ground and air forces. The Allies needed a victory.

On October 20, 1944, United States troops invaded Leyte as part of a strategy aimed at isolating Japan from the countries it had occupied in Southeast Asia. This would deprive Japanese forces and industry of vital oil supplies necessary for their war effort. The battle lasted for a little more than two months and became known for the debut of Japanese kamikaze suicide pilots. The battle was a decisive victory for the Allies, allowing them to begin a full-scale liberation of the Philippines.

Strategic Value of Guam

In summer 1944, the United States sought to retake the Marianas Islands, which included Guam, Saipan, and Tinian. These islands were essential to the United States to end World War II in the Pacific. The Marianas could cut the strategic line of communication from Japan to islands in the South Pacific and isolate garrisons stationed there. Guam was particularly important in implementing a successful victory in World War II because it allowed the United States use of the airfields to launch their B-29 bombers to initiate raids on the islands of Japan. Guam would also served as a submarine refueling point closer to enemy territory. Finally, Apra Harbor offered a good naval base. In July 1944, Allied forces retook the island of Guam, following weeks of intense fighting, leading to more than 7,000 American casualties and over 18,000 Japanese killed.

RADAR Plotting Scenario Teacher's Guide

Teacher Note: For the purposes of this activity, we have taken a RADAR Maneuvering Board and overlaid it on a map of the Pacific Theater, centering the location at the island of Iwo Jima. Distances are rounded in order to simplify calculations. Like all simulations, some liberty has been taken with historical accuracy, but the process and concept is designed to help students understand both the challenges and benefits of RADAR.

This document serves as a guide and script for the teacher:

Teacher: Today, you will be working in teams to plot an attack on an enemy convoy in the Pacific Theater. You will be provided with a Convoy Attack Team Planning Guide and Map for Plotting handout. You will need to listen carefully as I explain and provide you with the information needed to plot your attack.

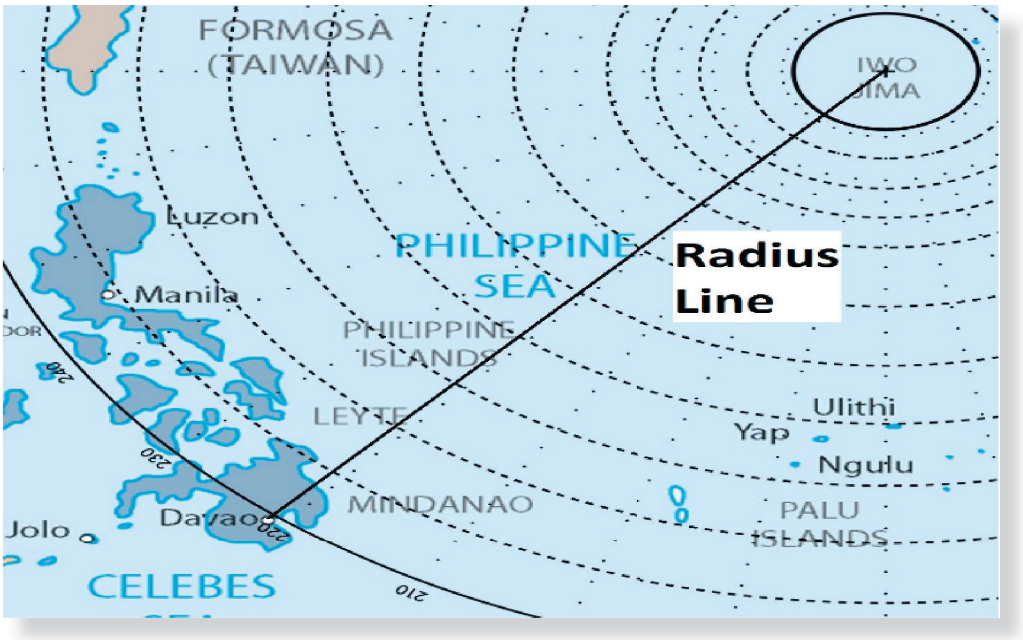
RADAR (RAdio Detection And Ranging) is a way to detect and study far off targets by transmitting a radio pulse in the direction of the target and observing the reflection of the radio pulse.

I will serve as the ping or pulse being sent out and reflected back to you. This means that I will give you the information about your enemy convoy as if I am the RADAR. Your job is to analyze the information I present you with and plot it on your Maneuvering Board and Map. From time to time, I will also pause and ask you to make calculations on your Convoy Attack Team Planning Guide Handout.

Step 1: Locate your own convoy. Your convoy is located in the center of the innermost circle on your Maneuvering Board. Please place a star on the location of your own convoy.

Step 2: Based on the provided Plotting Map, you must first determine the size of the region in which you are traveling (the area represented by the concentric circles.) If Iwo Jima is the center of the Maneuvering Board and the city of Davao, Philippines is at the outermost concentric circle of the Maneuvering Board, the radius line, showing the distance between the two points are 1,400 Nautical Miles or 2,575 kilometers.

RADAR Plotting Scenario Teacher's Guide cont.



Using the following formulas, answer the following questions for both nautical miles and kilometers.

1. What is the diameter of the Maneuvering Board (radius x 2)?

Nautical Miles	Kilometers
1,400 x 2 = 2,800 NM	2,575 x 2 = 5,150 km

2. What is the circumference of the Maneuvering Board (π x diameter)?

Nautical Miles	Kilometers
3.14 x 2800 = 8,792 NM	3.14 x 5,150 = 16,171 km

3. What is the area of the Maneuvering Board (π x radius^2)?

Nautical Miles	Kilometers
3.14 x 1,400^2 = 6,154,400 NM	3.14 x 2,575^2 = 20,820,162 km

RADAR Plotting Scenario Teacher's Guide cont.

When dealing with military operations, timing and location are of the utmost importance. Knowing the full area in which you are traveling (and more importantly, where the enemy is traveling) and your RADAR capabilities can be the difference between a sound victory or a bitter defeat.

Step 3: Your convoy is traveling in a northwest direction toward the enemy. We will begin by calculating your convoy's speed in knots. A knot is a unit of speed equal to one nautical mile (1.852 km) per hour. Your convoy is able to travel at a speed of 28 kph, or knots per hour. Calculate the speed in knots that your convoy is traveling.

Your Convoy's Speed in Knots: _____

Formula	*Answer*
KPH / NM	28 / 18.52 = 15.11 knots

Step 4: The enemy convoy is traveling at a speed of 20 knots. How many km/hour is the enemy convoy traveling?

The Enemy Convoy's Speed in kph: _____

- The methodology behind this question is the reverse of Step 3, here we are converting knots to KM. The necessary equation is #Knots multiplied by one nautical mile. 20 x 1.852 = 37.04kph.

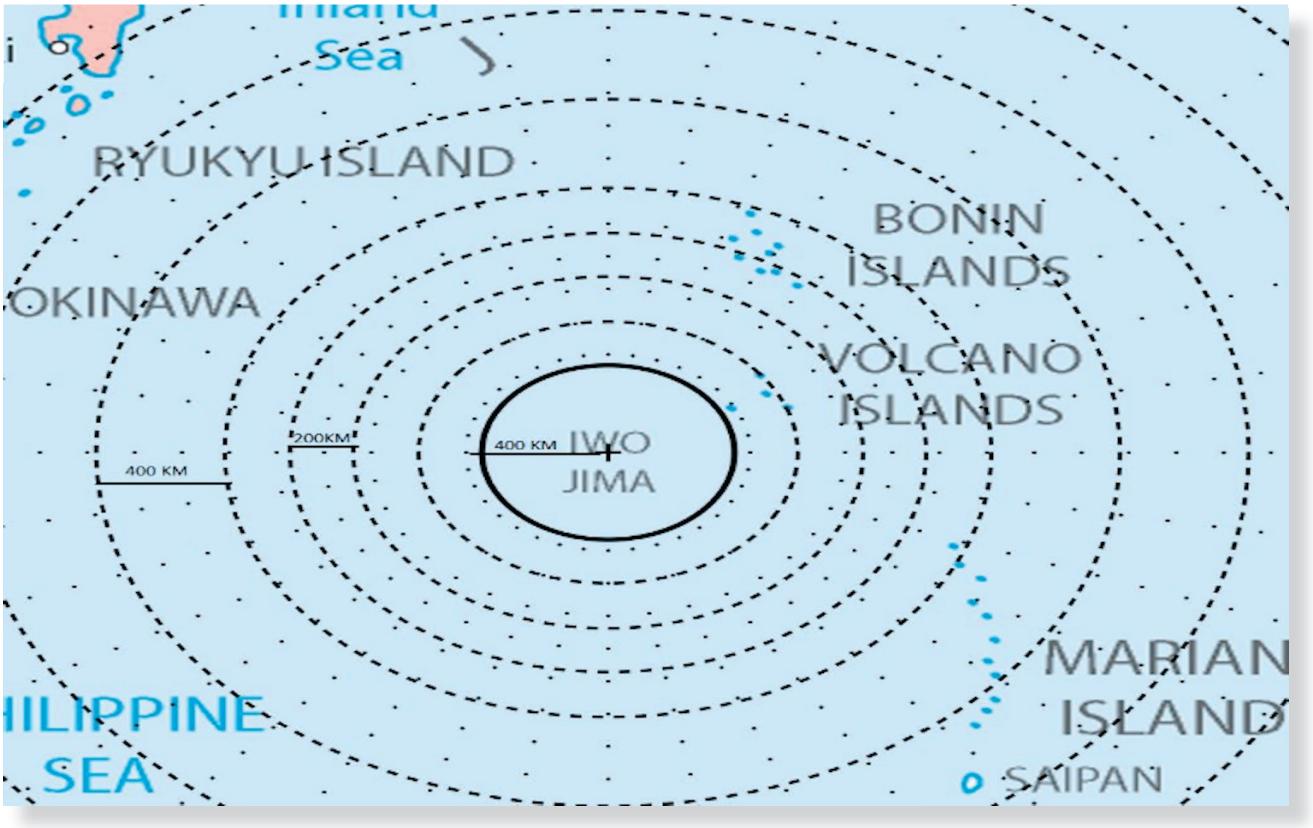
Formula	*Answer*
Knots x 1 NM	20 x 1.852 = 37.04 kph

Step 5: Plot the following enemy convoys on your Plot/Map:
(One large concentric circle represents 400km, one small (inner) circle represents 200 km, Iwo Jima to first concentric circle is 400 km)
1. northwest 320 degrees, 1,200 kilometers from your convoy (Open Water)
2. southeast 150 degrees, 2,000 kilometers from your convoy (Guam)
3. southwest 245 degrees 3,200 kilometers from your convoy (400 KM from Manila)
4. northeast 20 degrees, 500 kilometers from your convoy (Open Water)

RADAR Plotting Scenario Teacher's Guide cont.

5. southeast 225 degrees, 3,200 kilometers from Your Convoy (Leyte)

- Begin with the centerpoint of the maneuvering Board (Iwo Jima) and count the necessary circles to reach each plot point. As stated above, one large concentric circle represents 400km, one small (inner) circle represents 200 km, Iwo Jima to the first concentric circle is 400 km. Some enemy convoy points have been selected due to their impact in the war (Guam, Leyte) while the remaining enemy convoy points were selected at random.



Step 6: If target 4 (from **Step 5** above) is traveling at 20 knots, how long will it take to intercept our convoy (presuming we are stationary at Iwo Jima)? The following metrics have been provided to assist with the following question.
Distance = Speed x Time
Time = Distance/Speed
Speed = Distance/Time

Time it Will Take to Intercept our Convoy: _____

RADAR Plotting Scenario Teacher's Guide cont.

- Answer: 25 Hours. The equation needed is Time or Distance/Speed. As stated in Step 5, Target 4 is 500km way from our convoy. 500 km represents "distance." Next we have the rate of speed the enemy convoy is traveling, or 20 knots. As we currently have different measurements, we must now convert Knots to KPH or 20 x 1.852 = 37.04kph. 37.04 kph represents "speed." We now have the equation of distance/speed in kilometers. 500/37.04 = 13.5 or 13 hours, 30 minutes.

Step 7: In your team, plot your course of attack based on one of the enemy convoys location as seen in Step 5. You must decide how many vessels in your convoy will attack, how fast you will travel, and what path(s) you will take to get there. Please plot out your plan of attack on the Plot/Map provided. Please write out a justification for your decisions in the space provided.

- The Goal is for the students to select key strategic locations that were associated with the Pacific Theater (Guam and Leyte). Guam was selected due its strategic location, topography for airfields, harbors, and other strategic advantages. Leyte was chosen as it served as the site of the largest naval battle in the pacific.
- The teacher may want to share the following resources with students in order to help them see the strategic value in the locations of Guam and Leyte.
    - Map, *The Invasion of Leyte and the Battle for Leyte Gulf*
    - Strategic Value Cards for Plotting Team Activity

Teacher Note: The teacher may choose to add as many curve balls into the plotting process as they wish. You can change the locations of enemy ships based on updated RADAR information, adding to the number of enemy ships, etc.

Quick Write Assessment Rubric

	Advanced	Proficient	Basic	Emerging
Content and Analysis	The response contains a clear and controlled main idea and the topic is clearly communicated. The focus is strongly maintained for the purpose, audience, and task.	The response contains a clear claim. The claim demonstrates sufficient comprehension of the topic. The overall analysis follows logically from the text.	The response contains a claim, but it is not fully articulated. The claim demonstrates basic comprehension of the topic. Major points of textual analysis are missing or irrelevant to the purpose.	The response contains a minimal claim but does not demonstrate understanding of the topic. There is no clear purpose to the writing.
Use of Evidence	The response is well-supported by textual evidence throughout the entire analysis. The main idea and supporting details clearly connect to the evidence presented.	The response is fairly well supported by textual evidence, but contains gaps in the analysis. The main idea and supporting details mostly connect to the evidence presented.	The response is only partially supported by textual evidence and analysis is occasionally supported with significant gaps or misinterpretation of sources. There is little connection to the evidence presented.	The response demonstrates some comprehension of the idea of evidence, but only supports the claim with minimal evidence which is generally invalid or irrelevant.
Organization	The response has a clear and effective organizational structure, the topic is clearly communicated, and there is a logical progression of ideas from beginning to end.	The response has an evident organizational structure , the topic is mostly communicated, and there is an adequate progression of ideas from beginning to end.	The response has little to no organizational structure, the main idea is confusing, and there is little order to the progression of ideas from beginning to end.	There is no organizational structure, no main idea, and no progression of ideas from beginning to end.
Conventions and Grammar	The response demonstrates an above adequate command of conventions including: adequate use of correct sentence formation, punctuation, capitalization, grammar, and spelling.	The response demonstrates an adequate command of conventions: limited use of correct sentence formation, punctuation, capitalization, grammar, and spelling.	The response demonstrates minimal command of conventions: infrequent use of correct sentence formation, punctuation, capitalization, grammar, and spelling.	The response demonstrates no command of conventions: infrequent use of correct sentence formation, punctuation, capitalization, grammar, and spelling.