2827-A
3/15/33

Issue 15 July

Senior Class, 1934

1832

SEARCH PROBLEM

Issued - - - - - - - - - - - - - - - - - 15 July, 1933
Turn in Solution by 1200 - - - - - - 20 July, 1933
to
Supervising Clerk, Room N-11
for checking off.

DEPARTMENT OF OPERATIONS
Naval War College
Newport, R.I.
1 June 1933

- -

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2866
7-3-33

DEPARTMENT OF OPERATIONS

SCHEDULE OF EMPLOYMENT

Senior Class 1934

Period 17-20 July 1933

This period will be devoted to a Search Problem designed to familiarize officers with the standard methods of search.

The statement of the problem will be issued on 15 July.

Reference Publications required -

The Service of Information and Security
U.S. Fleet Aircraft Tactical Instructions Vol. I

will be drawn from the Archives when needed.

The schedule is as follows:

Monday, 17 July 0905 Senior Class assemble in Lecture Room for presentation of Problem.
Bring Problem statement to Lecture Room.
Solve Search Problem.

Tuesday, 18 July 0900 Continue solution.

Wednesday, 19 July 0900 Continue solution.

Thursday, 20 July 0900 Continue solution.
Issue staff solution.

1100 Senior Class assemble in Lecture Room for presentation of Staff Solution and discussion.

1200 Turn in solutions to Supervising Clerk in Room N-11.

R.B. Coffey,
Captain, U.S. Navy
Head of Department.

SEARCH PROBLEM

MOTIVE: Exercise in conduct of search operations.

ORANGE SITUATION: War exists between BLUE and ORANGE. BLUE has recently established her fleet at OKINAWA ISLAND, the ORANGE Fleet having retired to the INLAND SEA.

BLUE holds GUAM and the MARSHALL-CAROLINES.

ORANGE holds the BONINS, AMAMI-O-SHIMA, FORMOSA, the PHILIPPINES and the PELEWS and has sent an advance base force to the BONINS which will render PORT LLOYD (BONINS) secure after 6 April 1600.

ORANGE has been operating against BLUE lines of supply and has recently been so successful in destroying BLUE fuel convoys, that BLUE Fleet is practically immobilized due to shortage of fuel oil.

BLUE activities point toward a military expedition against ORANGE positions in the BONINS, NANSEI ISLANDS, or POLILLO (PHILIPPINES).

ORANGE Raiding Forces have been operating under Admiral OC. At the present time they are disposed as follows:-

In INLAND SEA -	Batcrudiv One, Crudiv Five (3 CC, 4 CA)
	Desrons Two, Three (24 DD, 2 CL)
At ULUTHI	Crudiv Nine (4 XCL)
At POLILLO	Crudiv Three (4 CL)
Off GUAM	Subdiv Seven less SS-5 (4 SS)
At sea (Lat. 20°N) (Long. 146°)	Crudiv Seven (4 CA)
At PELEWS	VP Squadron Six (4 VP)

In addition to the above forces subdivs Twenty-five and Twenty-six are on observation duty off TRUK. SS-37, due to an engine casualty, has recently started for the INLAND SEA at slow speed.

SPECIAL SITUATION:- On 3 April 0400 Admiral OC in CC-1 in the INLAND SEA receives the following delayed despatch from SS-49:-

"0101 LARGE BLUE CONVOY UNDER HEAVY ESCORT SAILED FROM TRUK TWELVE HUNDRED LOST CONTACT AT DARK LATITUDE ZERO EIGHT TWO ZERO LONGITUDE FIVE ONE THREE FIVE 2000".

On 3 April 0800 he receives the following despatch from SS-37:-

"0103 ENEMY FORCE TWO BATTLESHIPS FOUR CRUISERS MANY DESTROYERS LARGE TRAIN LATITUDE ONE TWO ZERO ZERO LONGITUDE FOUR SIX ZERO ZERO ON THREE APRIL ZERO SIX HUNDRED COURSE NORTHWEST SPEED ABOUT TWELVE HAVE LOST CONTACT 0700".

Admiral OC concludes that the two forces reported are the same and that it is either an expeditionary force to take the BONINS, NANSEI, or POLILLO or else a fuel convoy for the BLUE Fleet at OKINAWA. He issues the following order to all his force:-

"0103 INFORMATION LARGE BLUE CONVOY UNDER ESCORT TWO BATTLESHIPS FOUR CRUISERS MANY DESTROYERS SAILED FROM TRUK ONE APRIL TWELVE HUNDRED SIGHTED LATITUDE ONE TWO ZERO ZERO LONGITUDE FOUR SIX ZERO ZERO THREE APRIL ZERO SIX HUNDRED ON COURSE NORTHWEST GENERAL PLAN THIS FORCE WILL DESTROY BLUE CONVOY BY COORDINATED ATTACK IN ORDER TO PROTECT OWN BASES AND IMMOBILIZE BLUE FLEET TASKS STRIKING FORCE BATCRUDIV ONE CRUDIV FIVE DESRONS TWO THREE SUPPORT SCOUTING OPERATIONS PREPARATORY TO DECISIVE ENGAGEMENT WHEN ENEMY IS LOCATED INITIAL POSITION BONIN AREA FIVE APRIL PERIOD ULUTHI FORCE CRUDIV NINE SEARCH FROM FLANK TO NORTHWARD FROM BEARING TWO TWENTYFIVE FROM LAST REPORTED ENEMY POSITION SECTOR METHOD ON FOUR APRIL INDEPENDENT METHOD ON FIVE APRIL COVER ENEMY SPEED THIRTEEN TO TEN PERIOD BONIN GUARD

CRUDIV SEVEN SEARCH NORTHERN SECTOR RETIRING SEARCH PATROL TO WESTWARD INSURE ENEMY NONARRIVAL PORT LLOYD UNOBSERVED BEFORE SIX APRIL SIXTEEN HUNDRED PERIOD POLILLO FORCE CRUDIV THREE SEARCH OUT AND IN METHOD FROM FIVE APRIL ZERO FIVE HUNDRED SCOUTING LINE BEARING ZERO FROM SOUTHERN SCOUT IN LATITUDE ONE THREE THREE ZERO LONGITUDE THREE TWO THREE ZERO DISTANCE SIXTY COURSE EAST MAINTAIN LINE PERIOD GUAM FORCE SUBDIV SEVEN LESS SS FIVE TRAIL COURSE THREE ZERO FIVE PERIOD PELEW FORCE VP SQUADRON SIX OPERATE AS REQUESTED BY COMMANDER ULUTHI FORCE XRAY ASSUME DAYLIGHT ZERO FIVE HUNDRED TO NINETEEN HUNDRED AND ENEMY MAXIMUM SPEED THIRTEEN USE MINUS NINE TIME RENDEZVOUS INLAND SEA LOGISTICS AUXILIARIES REMAIN AT BASES SPECIAL PROVISIONS RADIO PLAN THREE PERIOD OPERATION ORDER TWELVE 0900".

The above operation order is received by all ships by 3 April 1200.

LOCAL SITUATIONS:

1. ULUTHI Force. This Force is fueling at ULUTHI and will not be ready to get underway until 1930 on 3 April. The aircraft of this force will not be used on 4 or 5 April.

At 0800 5 April Rear Admiral OCX commanding this force decides to advance his line as far as possible to the Northwestward during the night of 5-6 April and to request the PELEW Force to cover the area of his night run. Later in the day he sends following despatch to his own Force:-

"0105 FORM SCOUTING LINE BEARING FIFTY ONE DEGREES FROM XCL TWO IN LATITUDE ONE ZERO ZERO ZERO LONGITUDE THREE ZERO THREE ZERO AT ZERO FIVE HUNDRED SIX APRIL DISTANCE NINETY THREE SCOUT BY DIRECT METHOD COURSE NORTH WEST SPEED SEVENTEEN USE PLANES TO STARBOARD TO COVER INCREASED SCOUTING DISTANCE FIRST FLIGHTS TAKE OFF EACH SHIP AT ZERO SIX THREE ZERO OUT ON COURSE ZERO SEVEN FIVE FOR FIFTY TWO MILES THEN COURSE NORTHWEST RETURNING

TO SHIPS BY NINE HUNDRED MAKE SIMILAR FLIGHTS AT ELEVEN HUNDRED AND AT FIFTEEN THIRTY 1200".

2. BONIN GUARD:- At 1200 3 April this force is in Latitude 20° N., Longitude 146° E.

Weather conditions limit their speed to 20 knots until sunset of 5 April when improved weather assures Rear Admiral OCD in command of this force that he will be able to use maximum speed on 6 April.

After insuring that enemy cannot arrive at PORT LLOYD unobserved before 6 April 1600 he decides to continue his search patrol to the westward.

3. POLILLO Force:- On 5 April Rear Admiral OCE in command of this force receives orders to advance the line 140 miles by 6 April 0500. He transmits his order to his force and executes it at 1200 5 April.

During the afternoon of 5 April he intercepts message to the ULUTHI Force and plotting in their search for 6 April he decides to change his search to coordinate with theirs. He accordingly sends following message to his force:

"0106 AT ZERO FIVE HUNDRED SIX APRIL START SEARCH BY DIRECT METHOD COURSE NORTHWEST SPEED THIRTY 0200".

4. GUAM Force:- This force attempts attacks on BLUE Force during 3 April but vessels are kept down by destroyers without obtaining a sight of larger vessels so that by 4 April 0500 after charging batteries they can reach any desired positions on a line tangent to a circle of 100 miles radius from APRA.

5. PELEW Force:- This force at about 0900 5 April receives the following despatch from the Commander of the ULUTHI Force:

"0105 REQUEST GEOGRAPHICAL SECTOR BETWEEN BEARINGS THREE THREE ZERO AND ZERO THREE ZERO TO RADIUS OF THREE TWO ZERO MILES FROM MALAKAL HARBOR BE SEARCHED PRIOR TO FIVE APRIL NINETEEN HUNDRED 0800".

NOTE: See Chap. VII of "U.S. Fleet Aircraft Tactical Instructions Vol. I" in particular Article 754. It will be noted that this article uses the terms "after limiting bearing" and "forward limiting bearing". As used in this article the words 'forward' and 'after' refer to the course of an aircraft carrier from which the planes are sent. In this particular problem where the planes leave and return to a fixed point these words have no application. However, the question as to which limiting bearing is to be paralleled first is of considerable importance. The student will consider this in order to make the search in this problem most efficient.

ASSUMPTIONS:

1. Weather is clear, wind is light and sea smooth except as noted under LOCAL SITUATION for BONIN GUARD. Wind may be neglected in plotting plane flights.

2. Visibility is normal - The smoke of 8 or more ships can be seen 25 miles from any type of ship or plane.

3. All forces full of fuel.

4. No air force is available on ships except that each vessel of Crudiv Nine carries two VO(2) type 03U-1 sea planes capable of making a cruising speed of 87 knots for 3 hours with a reasonable margin for safety. These planes can be launched from launching track but on return must land on the water and ship must stop for 15 minutes to hoist each plane aboard.

5. The maximum and sustained speed of ships and VP planes is that listed in ANNEX A.

6. In constructing retiring search curves change course every three and one-half hours.

7. For convenience the position of the following are given:-

PORT LLOYD - Lat. 27°-05' N., Long. 142°-10' E.

POLILLO - Lat. 15°-00' N., Long. 122°-00' E.

MALAKAL HARBOR - Lat. 7°-19' N., Long. 134°-27' E.

ULUTHI (ULUTHI or MACKENZIE) Lat. 9°-53' N., Long. 139°-38' E. Note that from this position a run of at least 10 miles on course South is necessary before course can be safely changed to the Eastward.

8. To save labor in computation, a Table of Distances is appended as ANNEX B.

REQUIRED:

1. Plotting of tracks of individual ships and planes from time of taking first scouting station until 6 April 1900. The plot of run from present position to first scouting position is not required but the first scouting positions must be positions that could be reached. Use Strategic Plotting Chart No. 5050 Sheet No. 1.

2. What is maximum speed used by each vessel of ULUTHI Force during daylight 4 April?

3. Assuming that all ships received the order of Admiral OC, write out the despatches which the Commander, BONIN Guard would transmit to the vessels of his force in order to coordinate their movements during the nights of 4-5 April and 5-6 April.

NOTE: As to despatch sent upon receipt of Admiral OC's order see particularly paragraphs 389-395, "The Service of Information and Security".

As to despatch for night 4-5 April see particularly pages 174-175, "The Service of Information and Security".

As to despatch for night of 5-6 April the Commander of this force must consider how best to use the increased speed which he knows he can make the next day.

Will he increase the scouting distance and if so will he make this increase during the night or after dawn the next day? Which vessel will be the guide for the night retirement? Will the guide retire on radius from point where enemy was last sighted or toward possible destination?

4. In writing the despatches for 5-6 April consider the above points and brief the reasons for your decision.

5. What speed do vessels of Trailing Force use during night of 4-5 April and 5-6 April?

6. Assuming that BLUE maintains a straight course and a steady speed (10 to 13 knots) is it possible for the convoy to have been undetected up to 6 April 1900? If so indicate on your plot by cross hatching the areas in which the convoy could be at that time and also any areas in which he could have passed the scouting forces undetected.

7. For the PELEW Force - In which direction should the planes head while on the circumference of their sub-sectors in order to make the search most efficient?

8. What considerations governed the commander of the ULUTHI Force in selecting the sector to be searched by the planes of the PELEW Force?

ANNEX A

Ship and Plane Data

This data will be used although it differs in some respects from that contained in the current issue of the "ORANGE FLEET".

SHIP		Maximum speed	Sustained Speed	Sustained Radius	Economical Speed	Economical Radius
Crudiv Three	CL-21 to 24	33	30	2100	10	6000
Crudiv Seven	CA-36 to 39	33	30	3100	10	8000
Crudiv Nine	XCL-2	19	18	24000	-	-
	XCL-3 to 5	17	17	24000	-	-
Subdiv Seven	SS-1 to 4	18	15	4500	8	12550
VP6 (4 planes of PM-2 type)		100	76	973	-	-

VO(2) planes on Crudiv Nine - These planes are the O3U-1 type and have a cruising speed of 87 knots which they can maintain for 3 hours with a considerable margin for safety.

NOTE: Data not given for Striking Force as the plotting of the track of this force is not required.

2729A-B
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ANNEX B

TABLE OF DISTANCES.

Date	Time	Hours	Distance steamed at				Hours to reach PORT LLOYD by 6 April 1600	Corresponding distance at 13 knots
			13 kts	12 Kts	11 Kts	10 Kt		
3 Apr.	0600	0	0	0	0	0	82	1066
4 "	0500	23	299	276	253	230	59	767
4 "	0830	26.5	344.5	318	291.5	265	55.5	721.5
4 "	1200	30	390	360	330	300	52	676
4 "	1530	33.5	435.5	402	368.5	335	48.5	630.5
4 "	1900	37	481	444	407	370	45	585
5 "	0500	47	611	564	517	470	35	455
5 "	0830	50.5	656.5	606	555.5	505	31.5	409.5
5 "	1200	54	702	648	594	540	28	364
5 "	1530	57.5	747.5	690	632.5	575	24.5	318.5
5 "	1900	61	793	732	671	610	21	273
6 "	0500	71	923	852	781	710		
6 "	0830	74.5	968.5	894	819.5	745		
6 "	1200	78	1014	936	858	780		
6 "	1530	81.5	1059.5	978	896.5	815		
6 "	1900	85	1105	1020	935	850		

2827 B
3-15-33

CLASSES OF 1934

SEARCH PROBLEM

SOLUTION BY A MEMBER OF THE STAFF

Naval War College
Newport, R.I.
1 June, 1933.

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Classes of 1932

SEARCH PROBLEM

STAFF SOLUTION

The primary purpose of this problem is to give the student some familiarity with standard methods of search. The publication issued by the Navy Department which describes these standard methods of search is "The Service of Information and Security". "Aircraft Tactical Instructions, U.S. Navy 1924", also contains information on the use of aircraft in scouting.

In starting this problem, it should be noted that Strategic Plotting Chart No. 5050, Sheet No. 1, is a mercator projection. It is essential that all distances be measured in the mid latitude of the run concerned if an accurate plot is to be made.

It will save considerable calculation if a table showing the possible distances the enemy could steam by certain times is prepared. Such a table is appended to this solution.

The first step is to plot what is known of the enemy. Operation Order Twelve gives the following positions:

1 April 1200 Sailed from TRUK

3 April 0600 Lat. 12° N. Long. 146° E. This will be called point of departure.

Admiral OC had further information that at dark on 1 April the BLUE Force was southwest of HALL ISLAND, indicating that they had not taken a direct route.

When last sighted BLUE Force was on course NW making about 12 knots.

ULUTHI Force

This force is Crudiv Nine, consisting of XCLs 2, 3, 4, 5. XCL-2 can make a sustained speed of 18 knots. The others can sustain a speed of 17 knots.

From Operation Order Twelve we have "ULUTHI Force Crudiv Nine search from flank to Northward from bearing 225° from last reported enemy position, sector method on 4 April, independent method on 5 April. Cover enemy speed 13 to 10".

Lay off from Lat. 12°, Long. 146° (as the point of departure) the bearing 225° and on this radius plot the enemy position at 4 April 0500 for both 13 knots and 10 knots. These positions are about 190 and 220 miles, respectively, from ULUTHI. As Crudiv Nine does not finish fueling in time to sail before 1930, only 9.5 hours are available to reach these positions. The speed required is more than they can make. Therefore they can not reach the 4 April 0500 positions of the enemy on the assigned radius.

A mathematical solution of the possible meeting points is practicable, but it is simpler to use a trial and error system. Next, plot the 4 April 0830 enemy position on radius 225° from Lat. 12° N. Long. 146° E. for 13 knots and 10 knots. These positions are approximately 185 and 205 miles from ULUTHI. Thirteen hours are available, giving a speed of about 16 knots to the most distant position. This gives a margin, but not too much when it is remembered that the vessels must clear the anchorage after dark and skirt reefs that are none too accurately charted.

In the sector method of retiring search the vessel most distant from the enemy point of departure must steam at the highest speed. This makes it desirable that XCL-2 (the fastest scout) take the western station to cover an assumed enemy speed of 13 knots. We have already found that any one of the scouts can reach the eastern position, so this is satisfactory. The order of scouts from west to east will be XCL 2, 3, 4, and 5, covering assumed enemy speeds of 13, 12, 11 and 10 knots respectively.

The next point is to select the guide. The area between the track of any scout and the enemy point of departure is a triangle. These triangles are all similar. Two of their sides are in the ratios of the assumed enemy speeds (13:12:11:10 in this case) therefore the third sides are in the same ratios. This means that the speeds of the scouts must be in the ratios 13:12:11:10. If we assume that XCL-2 is the guide, the speed of each scout is as follows:

XCL - 2		18	Knots (her sustained speed)
XCL - 3	$\frac{12}{13}$ x 18 =	16.615	"
XCL - 4	$\frac{11}{13}$ x 18 =	15.231	"
XCL - 5	$\frac{10}{13}$ x 18 =	13.846	"

As the required speeds of XCL 3, 4, and 5 are less than their sustained speed of 17 Knots this is satisfactory and XCL-2 will be the guide.

If the sustained speed of any scout were less than her speed as computed above it would have been necessary to use that vessel as guide at her sustained speed. A re-computation of the required speeds for the other scouts would have been needed.

Now, on the radius 225° from Lat. 12° N. Long. 146° E. lay off enemy possible 0830 positions for 13, 12, 11 and 10 knots and mark these as 0830 positions of XCL 2, 3, 4 and 5 respectively.

Next plot the retiring search of XCL-2, (the guide).

Draw radii from the 1200, 1530, and 1900 positions of XCL-2 toward enemy point of departure (Lat. 12°N, Long. 146°E).

From 0830 position of each scout draw lines parallel to the course of XCL-2 to intersect the 1200 radius. These intersections give the 1200 positions for each scout. From these intersections draw lines parallel to the guides 1200 to 1530 run to intersect the 1530 radius giving the 1530 positions of the scouts. In the same way obtain the 1900 positions.

It is now desirable to check the plotting. This can be done most readily by measuring the scouting distances on each radius. The scouting distance equals the number of hours since enemy left point of departure, multiplied by the difference in assumed enemy speeds used by adjacent scouts. In this case the difference in assumed enemy speeds is one knot, so the scouting intervals should be as follows:

at 0830	26.5	miles
1200	30	"
1530	33.5	"
1900	37	"

If the plot does not give the above scouting distances, errors should be looked for.

A further check can be made by measuring the distances from the point of departure.

It is noted that the course of XCL-2 at about 1400 passes over the reef around SOROL or PHILIP ISLAND. A check shows that by using 0.5 knot of her reserve speed for 3.5 hours this reef could have been given a berth of 5 miles, which is ample. Such a use of reserve speed is permissible. If XCL-2 had no reserve speed it would be necessary for her to plot her possible 1530 position and notify the other scouts of the direction of the 1530 radius, in order that they might slow slightly to reach the same radius at 1530.

The night retirement of all scouts is along the 4 April 1900 radius. Each scout steams at the assumed enemy speed she is using. In plotting, it is sufficient to plot the guide XCL-2 and lay off the 5 April 0500 positions of other vessels at a scouting distance of 47 miles from XCL-2. If plotted in this way, it is advisable to check by measuring the distance from enemy point of departure to the two flank scouts.

During the second day, 5 April, this force used the independent method of search from the flank. The track of each

scout must be plotted separately. KCL-2 will use a scouting speed of 18 knots and the other vessels 17 knots. Each assumes the same enemy speed as on the previous day. KCL-2 runs 63 miles during each 3.5 hour period and the others run 59.5 miles. The plotting of this day's run presents no special features.

In planning to carry his line to the Northwest during the night of 5-6 April, Rear Admiral OCK first plotted the furthest positions, on the enemy of 6 April 0500 circles for 13 knots and 10 knots, that his flank scouts could reach. A line joining these two positions could not be reached by the two interior scouts, so the two flank scouts were moved back along the enemy daylight circles until a line was found which could be reached by all scouts, allowing a slight margin.

The area in which BLUE could be at 5 April 1900 and not be sighted by the ULUTHI Force, lies to Northward of the position of the Scouts at that time and between the 10 and 13 knot enemy position circles. The search to be made on the sixth will eliminate the possibility of the enemy having been at 5 April 1900 in the area a night's run from the daylight position of the scout line measured toward his point of departure, since if in this area at that time he would cross the scout line before daylight and be discovered during the sixth. Therefore the northern limit of the area in which BLUE could be at 5 April 1900 and still have a probability of escape is a line distant from the 6 April 0500 scout line by a night's run measured toward his point of departure. The area unsearched by the ULUTHI force is that shown on plot by lines of crosses and it is this area which Rear Admiral OCK decides to request the PELEWS Force to cover. (For strict accuracy, this area would be reduced by the visibility circles from the scouts 5 April 1900 and 6 April 0500 positions, also the above statements are based on the assumption that enemy has made good a speed of between 10 and 13 knots along a single course).

In plotting the run of the ships on 6 April 0500 to 1900, it must be noted that all scouts stop from 0900 to 0915, from 1330 to 1345, and from 1800 to 1815 to hoist aboard their planes.

In plotting the plane flights, it is noted that they must fly for 2.5 hours at 85 knots or 212.5 miles. They fly out 52 miles on course 75° and then take course N.W.

A little trial and error shows that they can make about

102.5 on course N.W. and must then head about 189° for 58 miles to rejoin their ships. Having plotted the flight of one plane, the other flights can be plotted by the use of parallel lines.

In planning these flights, it was realized that the probable course of the enemy was approximately West. This differentiates the present case from that of a search from ahead, as shown on Sketch No. 3, facing page 46 of "The Service of Information and Security". To fly the planes far ahead of the line of scouts in this case was an uneconomical use of them, and it was found best to have their flights be approximately abreast the scouts.

The plane visibility circle being 25 miles radius, the enemy at 13 knots could cross this in slightly less than 4 hrs., and it was therefore essential that the point where one plane turned toward its ship must be again visited by a plane within 4 hrs., in order to ensure completeness of the search. An additional allowance is also necessary on account of probable errors of plane navigation. As ordered, there is an interval of only 3 hours and 39 minutes between successive visits of planes to the same point. The above consideration does not apply during that part of the plane's flight which is abreast the scouts, for here BLUE if just out of sight of a plane, would be in sight of a scout, but it does apply to that part of the plane's flight not approximately abreast the scouts. Flights of 2 hours were tried and could not meet these conditions throughout the day. Flights longer than 2.5 hours required more total flying throughout the day and were, therefore, uneconomical. Largely by trial and error, flights were set at 2.5 hours.

PELEWS force

This force will be discussed next, as it must coordinate with the search of the ULUTHI Force.

The specific orders of this Force are as follows: "Request geographical sector between bearings 330 and 030 to radius of 320 miles from MALAKAL HARBOR be searched prior to 5 April 1900".

In addition to this, the task assignment of the ULUTHI Force is available in Operation Order Twelve, which also contains orders "PELEW Force VP Squadron Six operate as requested by Commander ULUTHI Force".

All these orders are at hand by 5 April 0900 and they are definite and specific. The commander of the VP Squadron may not fully understand how the operations requested assist the ULUTHI Force unless he later intercepts Rear Admiral OCX's message 0105-1200, but he nevertheless must act on them promptly.

The area which this search should deny to BLUE by 5 April 1900 has already been discussed and is that shown on the plot by the line of crosses.

"Plotting the search gives a distance each plane must run while on the circumference as 34 miles. This gives a total distance of 674 miles which at 76 knots requires 8 hours 52 minutes. If planes are to land by dark (1900) they must take off not later than 1008.

Having plotted the search it is now necessary to determine whether each plane is to parallel the eastern or the western limiting bearing on the way out. The simplest way of doing this is assume one direction and mark the area not covered on the way out and the area not covered on the way in. If the enemy can move from the former to the latter in the time available then there is a hole. The particular assumption to guard against in this problem is that the enemy keeps on a straight course at a speed between 10 and 13 knots. Under these assumptions if each plane first paralleled the western boundary of its sub-sector there would be no holes. Considering only one plane we find that the distance between the area unsearched on the way out and the area unsearched on the way in is such that the enemy could not have moved from one to the other in the time available. Examining the area between adjacent planes we find that the area unsearched on the way out lies to the west of the area unsearched

on the way in; this being the case the enemy could not have moved from the former to the latter without reversing his course and heading to the eastward.

Had the planes first paralleled the eastern boundaries of their sub-sectors there would have been possibilities of the enemy passing through undetected. The attached plot indicates such an area between the two eastern planes. The enemy could have been in the eastern part of the hatched area when the planes went out and have moved to the western part by the time the planes passed going in. Similar holes would exist between the other planes but these would be northwest of the area outlined in crosses and an enemy escaping through one of these would be detected on the next day by the ULUTHI Force, if he maintained his course and speed.

Under the ULUTHI Force reference has been made to the area outlined by crosses on the plot in which the enemy could have been at 5 April 1900 and escape detection by that force. This is the area that must be covered by the PELEW Force. The commander of the ULUTHI Force realizing that the planes of the PELEW Force must complete their search by dark figured that they would be on the circumference of the sector about five hours before dark. In selecting the sector to be searched he therefore put the eastern limit about 50 miles (5 hrs. at 10 kts) to the East of the area marked by crosses. Similiarly he realized that it was not necessary for the planes to search the extreme western part of this area as the enemy at 13 knots (his assumed max.speed) could not reach this part of the area by the times the planes would pass it."

BONIN GUARD

Orders for this force from Operation Order Twelve are as follows:

"BONIN Guard Crudiv Seven search Northern sector retiring search patrol to Westward. Insure enemy non-arrival PORT LLOYD unobserved before 6 April 1600".

The general instructions "Assume enemy maximum speed thirteen" also apply.

The force consists of CA-36, 37, 38 and 39, all capable of a sustained speed of 30 knots, but restricted by local weather conditions to 20 knots until the evening of 5 April.

From 3 April 0600 until 6 April 1600, when PORT LLOYD will be secure, is 82 hours. At 13 knots the enemy could in this time steam 1066 miles. Construct an ellipse having a major axis of 1066 miles and focii at PORT LLOYD and at Lat. 12° N. Long. 146°E. The distance from the enemy's point of departure to any point on this ellipse, thence to PORT LLOYD, is 1066 miles, therefore with a maximum speed of 13 knots the enemy could not run outside of ellipse and still endanger PORT LLOYD.

This force cannot reach a meeting point with BLUE on 3 April, but can probably occupy his 4 April 0500, 13 knot circle as far east as is necessary. Draw the enemy circle and at the same time draw the 13 knot limiting circle from PORT LLOYD. These two circles should intercept on the ellipse which will give a check on the drawing of the ellipse.

The distance between scouts is obtained by the formula

$d = r + \frac{rs}{E}$ $d = 25 + \frac{25x20}{13} = 25+38.5 =$ 63.5 miles.

After the search is underway, it is possible to increase this distance somewhat, so it is safe to space scouts 63.5 miles apart.

Try placing the eastern scout at 4 April 0500 on the enemy daylight circle where it intercepts the eastern side of the ellipse. Locate the other scouts at scouting distances of 63.5 miles to the westward along the daylight circle. This is a homogenous division, so Rear Admiral OCD should place the flagship CA-36 in the lead to the Westward, followed by the other scouts in normal order, CA-37, 38, and 39.

Now draw enemy 13 knot circles for 0830, 1200, 1530, and 1900. At the same time the corresponding limiting circles from PORT LLOYD can be drawn. Plot the retiring search curve of the leading scout CA-36. In 3.5 hour interval at 20 knots she will run 70 miles.

It is now necessary to check whether CA-39 was placed sufficiently far to the eastward or not, so plot her position for each 3.5 hour interval. These positions are marked A, B, C, D and E on the plot. It is next necessary to ascertain whether the points where the various limiting circles from PORT LLOYD intercept the path of the scouts are within sight from the corresponding positions of CA-39 (See par.390 "The Service of Information and Security"). It should be noted that after scouts have been under way a few hours their distance could have been increased to $d = \frac{2rs}{E} = \frac{2x25x20}{13} = 76.9$ miles. This means that what may be called an effective radius of visibility along their track is 38.5 miles. Examing the plot, the distance from B to the 0830 intersection is about 20 miles, from C to the 1200 intersection is about 30 miles, from D the distance is about 10 miles, and from E about 20 miles. These are all within the effective radius of visibility, so the original position of CA-39 was satisfactory. It might in fact have been moved a few miles westward if necessary.

A further check shows that all scouts can easily reach the selected 4 April 0500 positions. Rear Admiral OCD accordingly issued his orders by despatch as follows:

"Form scouting line normal order on enemy 4 April 0500 13 knot circle to westward from CA-39 in Latitude 15°57' N. Longitude 149°02' E. Scouting distance 63.5 miles. At 4 April 0500 start retiring search patrol to westward. Speed 20".

The positions of CA-37 and 38 at 4 April 1900 can be plotted from the positions already plotted for CA-36 and 39.

At 4 April 1900 to threaten PORT LLOYD the enemy must be north of the limiting circle from PORT LLOYD and to the southward or westward of the scouting line. Also he can not be north of his 13 knot circle from point of departure. This area is indicated on the plot by the small letters a-b-c-d-e-f-g-h. Rear Admiral OCD must for the next day establish his line in such a position that the enemy at 13 knots from any position within this area could not pass east of the scouts in time to threaten PORT LLOYD.

To lay off the 5 April 0500 position of the scouting line, draw a number of arcs of 130 miles (10 hrs. of darkness at 13 knots) radius to the Northeastward from the various points on the scouting line at 4 April 1900. (See pages 174 and 175 of "The Service of Information and Security"). The scouting line at 5 April 0500 must be beyond (to the Northeastward) these 130 miles radius arcs. The eastern scout should be on the limiting circle from PORT LLOYD, but it may be necessary to move this vessel farther to the eastward under the same considerations that governed the original position of the eastern scout. The western scout must be on the enemy's 5 April 0500 13 knot position circle. Distance between scouts must be not over 63.5 miles.

As a first assumption, Rear Admiral OCD places CA-39 on the intersection of a tangent, to the 130 mile radius arcs, and the limiting circle from PORT LLOYD, and from this point swings an arc with a radius of 190.5 miles, the length of the scouting line, to intersect the enemy 5 April 0500 13 knot

circle giving the position of CA-36. The other vessels are plotted between these two on the line joining them. Now plot the retiring search curve from CA-36 to the Westward.

It is now necessary to plot the positions of CA-39 for each 3.5 hours, points F, G, H, I, and J and determine if the enemy could have passed to the eastward of this vessel at any time during the day. A simple inspection shows that at F the limiting circle from PORT LLOYD passes through scouts position. Near points G and H the intersection of the respective limiting circles and the scouts track, lies only a few miles to the eastward of CA-39 at the corresponding time. The limiting circles for times corresponding to positions I and J are to the north of the scouting line and do not intersect. Rear Admiral OCD is then assured that the eastern scout is sufficiently far east. If necessary, he could have moved his line to the westward about 30 miles (the effective radius of visibility along line being 31.+ miles). This would leave no margin.

The local situation states that Rear Admiral OCD decides to continue search to the westward after insuring the safety of PORT LLOYD. He notes that by about 1330 his leading vessel crosses the ellipse, and if the enemy has not been sighted by this time he can not reach PORT LLOYD before it is secured. He therefore prepares his orders for the search on 5 April in ample time to issue them before 4 April 1900, as follows:

"At 5 April 0500 form scouting line normal order 117° from CA-36 in Lat. 21°23' N. Long. 142°09' E. Scouting distance 63.5 miles. Continue retiring search patrol to westward, speed 20".

By sunset 5 April Rear Admiral OCD knows that on the

following day he will be able to use a scouting speed of 30 knots. In planning his search for 6 April he has several things to consider, and he can make any one of several decisions, all of which are correct.

First, he knows that his scouting distance on 6 April can be $d = r + \frac{rs}{E} = 25 + \frac{25x30}{13} = 25 + 57.7 = 82.7$, say 82.5 miles. This will have a factor of safety, for after running a few hours the distance could be $d = \frac{2rs}{E} = \frac{2x25x30}{13} = 115.4$, or, say, 115 miles. The most effective way to use this is to station his vessels 82.5 miles apart at 6 April 0500. However, after the search starts, it would be desirable for the rear vessels to slow down to, say 20 or 25 knots until the distance has opened out to 115 miles. This would cover a lower enemy speed than would be covered if he maintained the distance of 82.5. If the rear scouts use less than 30 knots, we must recompute the safe scouting distance. An inspection of the above figures shows that the rear vessel can lose about 100 miles on the leader and still keep the line tight. Therefore, the rear scout could use 20 knots for about 10 hours befor speeding up to 30 knots. If this is done, then the line at dawn can not be opened out and scouting distance then must be 63.5 miles. The enemy can reach OKINAWA, a probable destination, early in the afternoon of 7 April, so it is desirable to carry the search to the westward as rapidly as possible in order to allow ORANGE Striking Force to engage on 6 April, or early on 7 April.

A compromise appears to be the best decision. Rear Admiral OCD, therefore, decides to open out the scouting distance to 73 miles (safe distance for 25 knots) during the night. At dawn, CA-36 will take 30 knots and CA-39 will take 25 knots. The other two scouts will take intermediate speeds, 26 2/3 and 28 1/2 knots. During the 14 hours of

daylight, the rear vessel steaming at 5 knots less than the leader will drop back 5x14 = 70 miles, making the length of the scouting line 3x73 + 70 = 289. One-third of this is 96.3 miles. This is apparently a safe spacing, for at 25 knots, the speed of the rear scout, $d = \frac{2rs}{E} = \frac{2x25x25}{13} = 96.1$ miles, so the line will be tight, although the leader has made as much distance as possible by using maximum speed.

Secondly, he must decide whether to retire from enemy point of departure or toward destination. There are several possible destinations, of which OKINAWA and AMAMI are the most likely. A retirement toward destination will advance search farther to the westward and might result in earlier discovery of enemy, but it will not as effectively cover the possible lower speeds of the enemy and will allow more chance of his slipping around the eastern end of the line. After considering probable areas covered by other forces, it seems best to retire away from Lat. 12°N. Long. 146°E, the enemy point of departure.

The new line must be outside the enemy's possible daylight position, that is at least 130 miles from the scouts' positions at 1900, 5 April.

Thirdly, Rear Admiral OCD must decide which vessel is to be the guide for the night retirement. The considerations here are exactly the same as given above, so he decides to make the eastern vessel the guide.

He can now plot his 6 April 0500 positions. CA-39 the guide, will retire 165 miles (this distance is necessary to put the new line 130 miles from line at sunset) away from the enemy point of departure. From this position draw a line tangent to the 130 mile arcs to intercept the enemy 6 April 0500 13 knot position circle. From the point where it intercepts the position circle extend the line along the circle.

We have decided that the distance between scouts, upon starting the search, should be 73 miles, therefore this line should be 219 miles in length.

The vessels are placed as shown on the plot.
Rear Admiral OCD can now issue his orders as follows:-
"By 6 April 0500, scouts form on scouting line as follows:

CA-36 Lat. 23-33 N. Long. 135-30 E.

CA-37 " 24-20 N. " 136-32 E.

CA-38 " 24-14 N. " 137-48 E.

CA-39 " 24-08 N. " 139-08 E.

Continue retiring search patrol to westward, CA-36 speed 30, CA-39 speed 25, other scouts intermediate speeds. When distance is opened to 96 miles all scouts take speed 30".

To plot the retiring search patrol, it is necessary to plot CA-36 at 30 knots. She steams 105 miles in each 3.5 hours. The others follow her track. Each commanding officer must compute the time at which he is to take up 30 knot speed.

POLILLO FORCE:

Original orders contained in Operation Order Twelve are as follows: "POLILLO Force, Crudiv Three search out and in method from 5 April 0500, Scouting line bearing 0° from southern scout in Lat. 13°-30' N. Long. 132°-30' E. Distance 60. Course East. Maintain line". The general paragraph "Assume enemy maximum speed 13", also applies.

Crudiv Three consists of CLs 21, 22, 23 and 24, all having a sustained speed of 30 knots.

Plot the original positions on scouting line. These scouts have 41 hours to get to position after receipt of orders. The distance is approximately 600 miles, so that all can easily reach assigned stations on time.

Compute the speed to maintain line as follows: 14 hrs. daylight times x knots equals 10 hrs. dark, times 13 kts.

$x = \frac{10 \times 13}{14} = 9.3$ knots.

Plot the run from 5 April 0500 to 5 April 1200 at this speed. At 1200, orders to advance the line 140 miles by 6 April 0500 are received. By standard usage, this means that the line at 6 April 0500 is to be 140 miles East of the line 24 hours earlier at 5 April 0500. (See pars. 149 to 151 "The Service of Information and Security").

To compute scouting speed -

Distance already advanced is 7x9.3 = 65.1.

New line must be 140-65.1 = 74.9 miles east of 1200 positions.

Can retire during dark 10x13 = 130 miles.

Must advance during remaining 7 hours of 5 April 130 + 74.9 = 204.9 miles.

Speed then is $\frac{204.9}{7}$ = 29.3 knots.

This is slightly less than the 30 knots these scouts can sustain.

Plot run to 1900 as 7x29.3 = 204.1 miles.

Plot run 5 April 1900 to 6 April 0500 as 130 miles to West.

An alternative proceedure for the search on 5 April would be as follows:- Compute the original speed to maintain the line allowing for the use of sustained speed at night rather than using only the assumed maximum enemy speed.

Using this alternative method the speed of advance to take at 5 April 0500 = x = $\frac{10x30}{14}$ = 21.43 knots.

At noon when new orders to advance the line 140 miles have been received the scouts have already advanced 7x21.43 = 150 miles. Therefore the new line to be reached by 6 April 0500 is 150-140 = 10 miles <u>West</u> of the noon position. There are only 7 hours of daylight left and 10 hours of night to retire in, so sustained speed of 30 kts., would be taken at noon. The speed of retirement to take at 1900 is then x and 10x = 7x30 + 10 = 220 and x = $\frac{220}{10}$ = 22.0 knots.

This alternative method is objectionable in that it uses an excessive amount of fuel and could accomplish nothing but a somewhat earlier discovery of the convoy. Considering possible enemy destinations and the location of other forces, early discovery hardly warrants the excessive fuel consumption which might prevent these vessels joining the engagement when the enemy is located. If this method is used the Northern vessel would cover an area already searched by the vessels of the GUAM Force for all speeds below 11.5 knots. The search also covers very low enemy speeds (7.1 knots for Southern scout to 8.3 knots for Northern scout).

Before reaching the last position Rear Admiral OCE has issued the following orders:- "At 6 April 0500 start search by direct method course Northwest, speed 30".

From 6 April 0500 to 6 April 1900 each vessel steams NW at 30 knots. This is a run of 420 miles.

In a search of this kind, the order of vessels makes little difference. The flagship CL-21 has been plotted as the southern scout. This facilitates reference to the order of vessels, but Rear Admiral OCE might have preferred his flag nearer the center of the line.

GUAM FORCE.

Original orders from Operation Order Twelve are as follows:-

"GUAM Force Subdiv Seven less SS-Five trail course 305°".

Local situation states that by 4 April 0500 this force can be anywhere on a line tangent to a circle of 100 miles radius from APRA.

The vessels of this force are SSs-1, 2, 3 and 4, all having a sustained speed of 15 knots, under command of Comsubdiv Seven, Comdr. OSBA.

Plot the line 305° from enemy point of departure (Lat. 12° N. Long. 146° E.).

Draw a line at right angles to the above line and tangent to a 100 mile arc from APRA. This is the line this force can reach by 4 April 0500.

The orders do not give Comdr. OSBA his scouting distance, so he sets this as 50 miles, being twice the radius of visibility. This is fairly conservative, for the BLUE force is large and with screen will cover a rather large area. He places his vessels two on each side of the line 305° already plotted. An order from Comdr. OSBA would be required to inform his force of these details.

Scouts at 4 April 0500 start on course 305° at their sustained speed of 15 knots until 1900. This is a run of 210 miles.

During the night the scouts trailing must not use too high a speed, or they might pass the enemy during darkness without sighting him. To compute this, we note that the line at 4 April 0500 was 217 miles from enemy point of departure. With the scouts run, they are now 210 + 217 = 427 miles from enemy point of departure, which he left 37 hours ago. To be ahead of the scouts at that time his speed must have exceeded $\frac{427}{37}$ = 11.5 knots (to nearest tenth). The scouts then can safely steam at 11.5 knots during darkness this night without danger of passing the enemy if he maintains course and speed.

(NOTE): It is sometimes assumed that at dark the enemy would be in sight if 25 miles ahead of the line and in sight at dawn if 25 miles in rear of the line. This assumption is not true if the enemy is abreast the space between the scouts. Therefore, it should be used only when most urgent to push the search forward at the sacrifice of completeness.

The run from 4 April 1900 to 5 April 0500 will be plotted at 11.5 knots, a distance of 115 miles.

Run from 5 April 0500 to 5 April 1900 is at 15 knots, a distance of 210 miles.

At 5 April 1900 scouting line is 217+ 210+ 115+ 210 = 752 miles from enemy point of departure, which he left 61 hours earlier. Speed for the coming dark period is therefore $\frac{752}{61}$ = 12.3 knots. Run from 5 April 1900 to 6 April 0500 is then 123 miles.

Run from 6 April 0500 to 6 April 1900 is at 15 knots, or a distance of 210 miles.

GENERAL

Requirements 2, 3, 4, 5, 7 and 8 have been answered in the preceding discussion.

Requirements 1, 2, 5, 6 and 7 are shown on attached plot. The cross hatched areas on plot show possible positions where enemy could have passed scouts undetected. In picking places where BLUE on a steady course and at a steady speed between 13 and 10 could have passed scouts, it is assumed that the 60 mile scouting distance used by the POLILLO Force was tight against a large convoy.

In the case of the BONIN Guard, it is noted that the leading scout has covered an enemy speed of 13 knots. The rear vessel has covered various enemy speeds. If we measure distances to the various positions of this rear scout, we find he has covered the following enemy speeds:-

At 4 April 0500 -- 13 knots

4 April 1900 -- 9.6 knots

5 April 0500 -- 10.3 knots

5 April 1900 -- 11.0 knots

6 April 0500 -- 11.2 knots

6 April 1900 -- 11.6 knots

The enemy at speeds slightly less than the above could be abreast the scouting line and cross to the eastward of it undetected. This cannot well be indicated on the plot.

2729A-B
6-2-32

ANNEX B

TABLE OF DISTANCES.

Date	Time	Hours	Distance steamed at 13 kts	12 Kts	11 Kts	10 Kt	Hours to reach PORT LLOYD by 6 April 1600	Corresponding distance at 13 knots
3 Apr.	0600	0	0	0	0	0	82	1066
4 "	0500	23	299	276	253	230	59	767
4 "	0830	26.5	344.5	318	291.5	265	55.5	721.5
4 "	1200	30	390	360	330	300	52	676
4 "	1530	33.5	435.5	402	368.5	335	48.5	630.5
4 "	1900	37	481	444	407	370	45	585
5 "	0500	47	611	564	517	470	35	455
5 "	0830	50.5	656.5	606	555.5	505	31.5	409.5
5 "	1200	54	702	648	594	540	28	364
5 "	1530	57.5	747.5	690	632.5	575	24.5	318.5
5 "	1900	61	793	732	671	610	21	273
6 "	0500	71	923	852	781	710		
6 "	0830	74.5	968.5	894	819.5	745		
6 "	1200	78	1014	936	858	780		
6 "	1530	81.5	1059.5	978	896.5	815		
6 "	1900	85	1105	1020	935	850		

AMAMI

OKINAWA

BONIN IDS.

130° 135° 140° 145° 150°

20° 15° 10°

5 Apr. 1900 1530 1200 0830 5 Apr. 0500

4 Apr. 1900 1530 1200 0830 4 Apr. 0500

13 Kts 6 April 1900

SS4 SS3 SS2 SS1 CA39 CA38 CA37 CA36 CL24 CL23 CL22 CL21 XCL5 XCL4 XCL3 XCL2

15 Kts 12.3 15 30 11.5 15 Kts

CL24 9.3 29.3 13 5 April 0500 5 April 1200

Stop 1800-15 1530 Stop 1330-45 1100 Stop 0900-15 0630

130 mi. 130 mi.

MAUG

GUAM

PELEW

Depart by 1008 to return by 1900 5 April

Hole only if planes head West on circumference of Sector

① 4 April 0500
② 4 April 1900
③ 5 April 0500
④ 5 April 1900
⑤ 6 April 0500
⑥ 6 April 1900

13.8 15.2 16.6 18 XCL5 XCL4 XCL3 XCL2 Soroi Id.

Blue 3 Apr. 0600 Course N.W. Sp. 12 +or-

CLASS OF 1934
SEARCH PROBLEM
STAFF SOLUTION

TRUK

Blue Convoy sailed 1 April 1200