A SYSTEMATIC APPROACH TOWARD DEVELOPING ASW TACTICS BASED ON PLAUSIBLE SOVIET RESOURCE ALLOCATION

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THESIS

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ALLOCATION

by

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ABSTRACT

This thesis relates the fact that, in the past, our ASW community has placed great (and justifiable) emphasis in detection and classification of submarines, while a serious lag in tactical procedures has developed. In order to alleviate this problem, it was felt that a systematic approach be taken which utilizes the principles of Operations Research.

By examining submarine warfare from the viewpoint of the Soviet Union, a resource allocation problem has been devised which compares the various submarine classes and the possible mission areas in which they may be assigned. Characteristics and available numbers of submarines were estimated, and the resulting allocation of forces was determined.

Although the analysis presented was based on hypothesized data, the strength in this approach lies in its flexibility and a wide range of applications. These features have been presented in Section III.

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I. INTRODUCTION AND BACKGROUND

The threat of submarine attack has been, from the period of the United States Civil War to the present, one of the most perplexing problems in warfare. A continuing struggle has been waged to produce new and more sophisticated detection devices and weaponry to combat this threat. Yet, with the advent of each anti-submarine measure has come increasingly sophisticated submarines and their associated striking powers. Tactics, too, have followed this continual see-saw in an effort by each side to gain some slight advantage over the other.

Today, the anti-submarine warfare community finds itself in a position of having to contend with a large variety of modern nuclear and conventional submarines, each with special operating characteristics and tasked with distinct operational objectives.

It has been noted that, "our usual attitude is along lines of long, reliable detection ranges with excellent classification characteristics."[1] In essence, we have placed great (and justifiable) emphasis in detection and classfication, while a serious lag in tactical procedures has developed. In view of the variety of undersea weapons platforms our potential adversaries are continually producing, we must take positive and carefully formulated corrective measures to alleviate this situation.

This paper utilizes the principles of Operations Analysis to direct our anti-submarine tactical methodology toward the specific threats we are most likely to face in our various naval operations. By accepting the premise that the Soviet Union has developed a systematic allocation

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[1] Anti-Submarine Warfare Laboratory Report No. NADC-AW-N5906, Future Detection and Classification Methods in Anti-Submarine Warfare (U), p. 1, 5 March 1959 (SECRET document).

of its submarine resources, we will be able to anticipate both the strength, and nature of the forces we may oppose in a wartime environment.

II. ANALYSIS

A. DEVELOPMENT

It is the goal of this paper to provide a systematic approach toward examining Soviet submarine resources, the various mission areas in which these resources may be utilized, and ultimately, the allocation of these assets. With full realization of the rapidly expanding Soviet naval posture and the recent advances of their technology, it is reasonable to assume that they currently employ Operations Research/ Systems Analysis principles in much the same manner as do Western scientists. In this regard, Admiral of the Fleet of the Soviet Union S.G. Gorshkov stated, "We have had to cease comparing the number of warships of one or another type and their total displacement (or the number of guns in a salvo, or the weight of this salvo), and turn to a more complex, but also more correct appraisal of the striking and defensive power of ships, based on a mathematical analysis of their capabilities and quantitative characteristics."[2]

Putting ourselves behind the desk of the top military decision makers in the Kremlin we will view the submarine warfare picture through "red colored glasses" and develop an optimal solution to the problem of submarine allocation. By adopting this method of analysis we will determine a rational approach we might expect the Soviet analysists to take in submarine mission assignments, and will therefore facilitate optimizing U.S. ASW tactics to counter our most likely opponents.

Visualize, if you will, Admiral Gorshkov calling to his office, the leaders of the Soviet Navy. He has before him, two charts; one showing

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[2] Gorshkov, S. G., "Navies in War and in Peace," United States Naval Institute Proceedings, Vol. 100, Number 1, p. 19-20, January 1974.

the sixteen submarine types currently serving the fleet, and the other showing the ten missions on which these submarines are likely to be employed. Figure 1 lists the submarines and missions under consideration. To the leaders assembled before him, Admiral Gorshkov assigns the task of determining an "optimal" allocation of the submarine fleet. The scenario he prescribes is one in which the U.S. has refused to heed numerous grave warnings issued by the Soviet Union. As a result of repeated U.S. threats to the freedom of the Soviet people, all-out war is close at hand.

Upon leaving Admiral Gorshkov's office, the leaders decide to present this problem to their military analysisists.

After several weeks, the Naval Analysis Branch presents to the leaders, a report containing several alternatives from which Admiral Gorshkov and his staff select the linear program discussed below.

B. LINEAR PROGRAM

Table I displays a resource-mission matrix[3] in which the pertinent submarine capabilities and limitations have been examined in order to determine which of the mission areas each type of submarine would be likely to be assigned. This table shows that four of the original six mission areas have been subdivided. The anti-convoy mission has been expanded to include missions whose sole objective is to sink merchant vessels, and missions tasked with

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[3] It is important to note that to preclude the necessity of security classification, submarine characteristics and total numbers available have been approximated, and are presented for purposes of illustration. These numbers are consistent with those currently available in unclassified sources.

destroying specific cargos (petroleum, steel, armament, etc.). The anti-United States Task Group mission area has been subdivided into missions aimed at placing aircraft carriers out of commission, and missions designed to destroy carrier defenses. The missions designed to strike continental U.S. targets have been divided into those to strike industrial areas and those to strike SAC bases. Barrier patrols have been redefined to be patrols to counter the submarine threat, and barriers to counter the surface ship threat.

The characteristics for each submarine type listed in Table I were used to determine possible missions for each submarine class. Ranges have been divided into short (S), medium (M), and long (L). Speeds are listed as slow (S) for those whose maximum submerged speed is less than, or equal to sixteen knots, and fast (F), for those capable of submerged speeds in excess of sixteen knots. The category of power was divided into conventional (C), and nuclear (N). Weapons loads for the various submarines are torpedoes (T), guided missiles (G), and ballistic missiles (B). Notice that, in all cases, those classes of submarines which are armed with missiles also carry torpedoes. In addition, because it is unreasonable to expect that all submarines are available at any given time, the number of each submarine type available has been chosen to be eighty percent of the totals.

In Table I, an X represents the decision that a submarine of type i would be a reasonable choice to fulfill mission j. For example, a Z class sub might be assigned to counter merchant shipping, but due to the submarine's characteristics, would be a poor choice in a role against U.S. Task Groups.

The decision was made to formulate a linear program which maximized the utility of the submarine fleet, subject to the constraints that all

mission areas were to be fulfilled, and that the number of submarines of each type was not to be exceeded.

In order to meet this objective, each class of submarine was compared with a reference class (in this case, the Y class was chosen). The subjective determination was then made as to the "value" of a submarine of type i. Based on the age of each class and its overall contribution toward insuring the security of the U.S.S.R., these values were assigned to the classes as shown in Table II. For example, one Y class submarine is "worth" nine E class subs. Another way of viewing these values is to answer the question; "The loss of how many E class submarines is equal to the loss of one Y class sub?" Due to the nature of the objective function, and in order to facilitate computations, a base value of one was chosen for the Y class submarines.

Next, the marginal utility of each submarine in its possible mission areas was determined. By examining the requirements of each mission, and by knowing how much a given submarine contributes toward the mission, these quantities were calculated. Marginal utility values are shown in Table II. For example, each H class submarine represents three percent of the total requirement needed against U.S. SAC bases. Stated in different terms, using only H class submarines to counter U.S. SAC bases, 33.3 subs would be needed.

In mathematical notation, the linear program is as follows:

Maximize
$$z = \sum_{j=1}^{10} \sum_{i=1}^{15} V_{ij} X_{ij}$$

Subject to
$$\sum_{j=1}^{10} X_{ij} \leq b_i \forall \quad i$$

$$\sum_{i=1}^{15} a_{ij} X_{ij} = 1 \forall \quad j$$

$$X_{ij} \geq 0 \quad \forall\ i, j$$

where V_{ij} ≡ the value of a submarine of type i on mission j[4],

X_{ij} ≡ the total number of submarines of type i used on mission j,

b_i ≡ the total number of type i submarines available,

a_{ij} ≡ the marginal utility of type i

Note that the expression $\sum_{i=1}^{15} a_{ij}X_{ij}=1 \ \forall_j$ is the constraint that all missions be fulfilled[5].

With the objective function and the constraint equations listed above, and the marginal utilities and values shown in Table II, a computer program was written to determine an optimal allocation of the available submarines. Table III illustrates the values determined.

It was seen that in several instances two or three classes of submarines were similar in that they were capable of performing the same missions, and had been assigned similar values and marginal utilities.

To simplify the linear program, a revised matrix utilizing combined marginal utilities, and averaged values was determined. This matrix is shown in Table IV. Table V displays the corresponding solutions to the linear program. It is readily seen that combining classes of submarines

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[4] While each submarine type has been assigned a value, it must be noted that V_{ij} is zero in many cases. For example, the value of a Z class sub against merchant shipping is 20, while its value against CVA's is zero.

[5] In the context of this analysis "fulfilled" means that the missions are to be accomplished to some input degree. For example, to fulfill the convoy mission does not necessarily mean that all convoy ships are sunk. The actual value of the target amounts would then constitute different Soviet Strategies.

affected the solution very little.

The computer analysis used in the preparation of this paper was conducted using the Mathematical Programming System (MPS-360) package in conjunction with an IBM-360 computer. It is felt that MPS-360 is an excellent tool in such analyses, and has special merits, in that the capability to perform sensitivity analyses is incorporated into the system. A listing of the computer program and output follows Section III. Also, see Ref. 4 for detailed instructions concerning the use of MPS-360.

III. DISCUSSION AND CONCLUSIONS

It is recognized that in formulating the linear program described in Section II from the viewpoint of the Soviet Union, a rather "simplistic" approach was taken. Obviously, by utilizing detailed intelligence information as inputs, outputs more closely approximating the real world could have been obtained. In addition, by defining marginal utility to mean "missions per submarine," some economists might argue that it is unreasonable to expect that each submarine added to a particular mission area contributes the same amount toward fulfilling the goal of the mission as did the previous submarine (i.e., is it reasonable to assume that marginal utilities are constant?).

Often, we have been content to rely on World War II methods which were successful before the emergence of the nuclear submarine. From these outdated tactics we have devised tactics for implementation in today's Navy. Our current tactical publications consist of numerous procedures limited in scope, and general in nature. Is it not reasonable to expect that with the specialized nature of our current naval missions we may anticipate encountering adversaries equally specialized? Such a redundant question should certainly point towards devising new tactics designed to meet a modern challenge.

A closer examination of the methods presented in this paper reveals that through the use of the linear program we are able to conduct meaningful sensitivity analyses. By fixing one input we may examine the range of other variables for which a given solution remains unchanged. For example, we may ask the question, "Assuming that the characteristics of the other classes of Soviet submarines do not change, how will the adversaries we may expect to face vary as a particular class of

submarines is phased out of service, or new classes are introduced?"

In addition, we may use the outputs generated by this model to evaluate current tactics. For example, by analyzing a given tactic we may be able to predict the type of submarine characteristics most vulnerable to that tactic. Then by determining on which of our missions we would be most likely to encounter those submarines, we will be able to conduct more specific training to strengthen our capabilities. In recent years there have been encouraging results from experimental tactics evaluated during fleet exercises[6]. Certainly, the information resulting from this linear program can serve to amplify our belief that these new tactical methods have merit in given circumstances, and we will be able to evaluate alternative courses of action.

Perhaps even more importantly, use of these methods will enable us to evaluate the overall effects of a change in tactics in a given area. For example, a new CVA screening tactic cannot be expected to result in greater survivability of the CVA if the enemy elects to commit proportionally greater submarine assets to the anti-CVA mission. In this case, the value of the new screen tactic will be manifested in increased survivability of the target of some other submarine mission. The identity of this target, and the magnitude of the savings might be estimated from this program.

Application of the linear program presented here is not restricted to the all-out war scenario described, nor is it limited to the characteristics of the submarines listed. In a limited war in which one or more missions described in the analysis are not applicable, the linear program may easily be modified. Similarly, as new submarine classes are

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[6] See Ref. 2.

established or as new missions are foreseen, this approach may also be used.

Without question there are many avenues yet to be examined in regard to the implementation of such an approach to our ASW. In particular, devising new tactics suggested by the output of the linear program will require detailed development of the input variables. When assigning actual marginal utilities to submarine missions, the scope and nature of the missions must be very thoroughly analyzed. For example, by stating that 20 submarines of type i are required to fulfill mission j, we must be willing to estimate both the mission objectives and the submarine capabilities in considerable detail.

It has not been the intent of this paper to provide "the" answer to the difficulties facing our current ASW endeavors. Rather, the methods presented here are offered as one logical approach to ASW, designed to eliminate some of the guesswork and outmoded bases which now serve as foundation for much of our efforts.

Used as a tool, the linear program and extensions of the methods presented here will enable our policy makers to take a fresh look at the many and varied apsects of Anti-Submarine Warfare.

SUBMARINE TYPES		MISSION AREAS
B	P	DEFEND HOMELAND
C	Q	ANTI-MERCHANT SHIPPING
E	R	ANTI-CONVOY
F	V	ANTI-U.S. TASK GROUP
G	W	BARRIER PATROL
H	W (conv)	STRIKE CONTINENTAL U.S. TARGETS
J	Y	
N	Z	

SUBMARINE TYPES AND MISSION AREAS

Figure 1

RE-SOURCE	RANGE	SPEED	POWER	WEPS.	TOTAL	AVAIL.	MISSION									
							mer-ship	convoy		task-group		cont. U.S.		defend	anti-barrier	
								hulls	cargo	CVA	DD's	SAC	indus.	USSR	sub	surf.
Q	S	S	C	T	10	8		X	X							X
B	M	S	C	T	5	4		X						X		X
W	M	S	C	T	35	32		X						X		X
R	M	S	C	T	15	12		X						X		X
Z	L	S	C	T	10	8	X	X	X							
F	L	S	C	T	50	40	X	X	X							
W(conv)	M	S	C	G/T	5	4				X	X			X		X
J	L	S	C	G/T	15	12				X	X			X		X
G	L	S	C	B/T	20	16						X	X	X		X
N	L	F	N	T	15	12			X		X			X	X	X
V	L	F	N	T	15	12			X		X			X	X	X
E	L	F	N	G/T	25	20				X			X	X		
P/C	L	F	N	G/T	20	16							X			
H	L	F	N	B/T	10	8						X	X	X	X	X
Y	L	F	N	B/T	40	32						X	X			

RESOURCE-MISSION MATRIX

TABLE I

RE-SOURCE	VALUE	MISSION									
		mer-ship	convoy		task-group		cont. U.S.		defend	anti-barrier	
			hulls	cargo	CVA	DD's	SAC	indus.	U.S.S.R.	sub	surf.
Q	25		.03	.02							.03
B	24		.04						.03		.04
W	23		.05						.04		.05
R	23		.06						.05		.05
Z	20	.05	.08	.06							
F	20	.04	.06	.05							
W(conv)	17				.10	.10			.10		.11
J	17				.12	.10			.12		.13
G	17						.01	.04	.08		.07
N	15			.11		.09			.07	.05	.09
V	13			.10		.08			.07	.07	.09
E	9				.12			.03	.06		
P/C	7							.03			
H	5						.03	.06	.08	.08	.06
Y	1						.04	.07			

MARGINAL UTILITIES

TABLE II

RE-SOURCE	MISSION mer-ship	convoy hulls	convoy cargo	task-group CVA	task-group DD's	cont. U.S. SAC	cont. U.S. indus.	defend USSR	anti-barrier sub	anti-barrier surf.	AVAIL.	USED	SLACK
Q			8.00								8	8	–
B								4.00			4	4	–
W		10.64						13.56		7.80	32	32	–
R										12.00	12	12	–
Z			8.00								8	8	–
F	25.00	7.80	7.20								40	40	–
W(conv)				4.00							4	4	–
J				5.00	7.00						12	12	–
G						16.00					16	16	–
N									12.00		12	12	–
V					3.75			2.54	5.71		12	12	–
E							17.33	2.67			20	20	–
P/C							16.00				16	16	–
H						7.83				.17	8	8	–
Y						2.37					32	2.37	29.63

OPTIMAL ALLOCATION　　　Z = 3842

TABLE III

RESOURCE	VALUE	MISSION									
		mer-ship	convoy		task-group		cont. U.S.		defend	anti-barrier	
			hulls	cargo	CVA	DD's	SAC	indus.	USSR	sub	surf.
Q	25		.03	.02							.03
B,W,R	23		.05						.04		.05
Z,F	20	.04	.06	.05							
W(c), J	17				.12	.10			.12		.13
G	17						.01	.04	.08		.07
N,V	14			.10		.08			.07	.06	.09
E	9				.12			.03	.06		
P/C	7							.03			
H	5						.08	.06	.08	.08	.06
Y	1						.09	.07			

MARGINAL UTILITIES (MODIFIED)

TABLE IV

RESOURCE	MISSION										AVAIL.	USED	SLACK
	mer-ship	convoy		task-group		cont. U.S.		defend	anti-barrier				
		hulls	cargo	CVA	DD's	SAC	indus.	USSR	sub	surf.			
Q			8.00								8	8	-
B,W,R		12.56						15.44		20.00	48	48	-
Z,F	25.00	6.20	16.80								48	48	-
W(c),J				8.33	7.67						16	16	-
G						16.00					16	16	-
N,V					2.92			4.42	16.67		24	24	-
E							18.78	1.22			20	20	-
P/C							14.55				16	14.55	1.45
H						8.00					8	8	-
Y						2.22					32	2.22	29.78

OPTIMAL ALLOCATION (MODIFIED)

TABLE V

Z = 3468

```
MPS-PTF4          EXECUTOR.     MPS/360 V2-M10

SOLUTION    (OPTIMAL)

TIME =   0.90 MINS. ITERATION NUMBER =     43

            ...NAME...       ...ACTIVITY...        DEFINED AS

            FUNCTIONAL        3482.37222           VALUE
            RESTRAINTS                             ALOT1
```

MPS-PTF4 EXECUTOR. MPS/360 V2-M10

SECTION 1 - ROWS

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	VALUE	BS	3482.37222	3482.37222-	NONE	NONE	1.00000
2	SUB1	UL	8.00000	.	NONE	8.00000	24.64444-
3	SUB2	UL	4.00000	.	NONE	4.00000	23.44444-
4	SUB3	UL	32.00000	.	NONE	32.00000	22.25926-
5	SUB4	UL	12.00000	.	NONE	12.00000	22.25926-
6	SUB5	UL	8.00000	.	NONE	8.00000	18.93333-
7	SUB6	UL	40.00000	.	NONE	40.00000	19.11111-
8	SUB7	UL	4.00000	.	NONE	4.00000	15.64969-
9	SUB8	UL	12.00000	.	NONE	12.00000	15.37963-
10	SUB9	UL	16.00000	.	NONE	16.00000	16.88889-
11	SUB10	UL	12.00000	.	NONE	12.00000	14.07407-
12	SUB11	UL	12.00000	.	NONE	12.00000	11.70370-
13	SUB12	UL	20.00000	.	NONE	20.00000	7.88889-
14	SUB13	UL	16.00000	.	NONE	16.00000	5.88889-
15	SUB14	UL	8.00000	.	NONE	8.00000	4.11111-
16	SUB15	BS	2.37222	29.62778	NONE	32.00000	.
17	MIS1	EQ	1.00000	.	1.00000	1.00000	22.22222-
18	MIS2	EQ	1.00000	.	1.00000	1.00000	14.81481-
19	MIS3	EQ	1.00000	.	1.00000	1.00000	17.77778-
20	MIS4	EQ	1.00000	.	1.00000	1.00000	13.50309-
21	MIS5	EQ	1.00000	.	1.00000	1.00000	16.20370-
22	MIS6	EQ	1.00000	.	1.00000	1.00000	11.11111-
23	MIS7	EQ	1.00000	.	1.00000	1.00000	37.03704-
24	MIS8	EQ	1.00000	.	1.00000	1.00000	18.51852-
25	MIS9	EQ	1.00000	.	1.00000	1.00000	18.51852-
26	MIS10	EQ	1.00000	.	1.00000	1.00000	14.81481-

SECTION 2 - COLUMNS

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
27	X11	LL	.	.	.	NONE	24.64444-
28	X12	LL	.	25.00000	.	NONE	.08889-
29	X13	BS	8.00000	25.00000	.	NONE	.
30	X14	LL	.	.	.	NONE	24.64444-
31	X15	LL	.	.	.	NONE	24.64444-
32	X16	LL	.	.	.	NONE	24.64444-
33	X17	LL	.	.	.	NONE	24.64444-
34	X18	LL	.	.	.	NONE	24.64444-
35	X19	LL	.	.	.	NONE	24.64444-
36	X110	LL	.	25.00000	.	NONE	.08889-
37	X21	LL	.	.	.	NONE	23.44444-
38	X22	LL	.	24.00000	.	NONE	.03704-
39	X23	LL	.	.	.	NONE	23.44444-
40	X24	LL	.	.	.	NONE	23.44444-
41	X25	LL	.	.	.	NONE	23.44444-
42	X26	LL	.	.	.	NONE	23.44444-
43	X27	LL	.	.	.	NONE	23.44444-
44	X28	BS	4.00000	24.00000	.	NONE	.
45	X29	LL	.	.	.	NONE	23.44444-
46	X210	LL	.	24.00000	.	NONE	.03704-
47	X31	LL	.	.	.	NONE	22.25926-
48	X32	BS	10.64000	23.00000	.	NONE	.
49	X33	LL	.	.	.	NONE	22.25926-
50	X34	LL	.	.	.	NONE	22.25926-
51	X35	LL	.	.	.	NONE	22.25926-
52	X36	LL	.	.	.	NONE	22.25926-
53	X37	LL	.	.	.	NONE	22.25926-
54	X38	BS	13.56250	23.00000	.	NONE	.
55	X39	LL	.	.	.	NONE	22.25926-
56	X310	BS	7.79750	23.00000	.	NONE	.
57	X41	LL	.	.	.	NONE	22.25926-
58	X42	LL	.	23.00000	.	NONE	.14815-
59	X43	LL	.	.	.	NONE	22.25926-
60	X44	LL	.	.	.	NONE	22.25926-
61	X45	LL	.	.	.	NONE	22.25926-
62	X46	LL	.	.	.	NONE	22.25926-
63	X47	LL	.	.	.	NONE	22.25926-
64	X48	LL	.	23.00000	.	NONE	.18519-
65	X49	LL	.	.	.	NONE	22.25926-
66	X410	BS	12.00000	23.00000	.	NONE	.
67	X51	LL	.	20.00000	.	NONE	.04444-
68	X52	LL	.	20.00000	.	NONE	.11852-
69	X53	BS	8.00000	20.00000	.	NONE	.
70	X54	LL	.	.	.	NONE	18.93333-
71	X55	LL	.	.	.	NONE	18.93333-
72	X56	LL	.	.	.	NONE	18.93333-
73	X57	LL	.	.	.	NONE	18.93333-
74	X58	LL	.	.	.	NONE	18.93333-
75	X59	LL	.	.	.	NONE	18.93333-

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
76	X510	LL	.	.	.	NONE	18.93333-
77	X61	BS	25.00000	20.00000	.	NONE	.
78	X62	BS	7.80000	20.00000	.	NONE	.
79	X63	BS	7.20000	20.00000	.	NONE	.
80	X64	LL	.	.	.	NONE	19.11111-
81	X65	LL	.	.	.	NONE	19.11111-
82	X66	LL	.	.	.	NONE	19.11111-
83	X67	LL	.	.	.	NONE	19.11111-
84	X68	LL	.	.	.	NONE	19.11111-
85	X69	LL	.	.	.	NONE	19.11111-
86	X610	LL	.	.	.	NONE	19.11111-
87	X71	LL	.	.	.	NONE	15.64969-
88	X72	LL	.	.	.	NONE	15.64969-
89	X73	LL	.	.	.	NONE	15.64969-
90	X74	BS	4.00000	17.00000	.	NONE	.
91	X75	LL	.	17.00000	.	NONE	.27006-
92	X76	LL	.	.	.	NONE	15.64969-
93	X77	LL	.	.	.	NONE	15.64969-
94	X78	LL	.	17.00000	.	NONE	.50154-
95	X79	LL	.	.	.	NONE	15.64969-
96	X710	LL	.	17.00000	.	NONE	.27932-
97	X81	LL	.	.	.	NONE	15.37963-
98	X82	LL	.	.	.	NONE	15.37963-
99	X83	LL	.	.	.	NONE	15.37963-
100	X84	BS	5.00000	17.00000	.	NONE	.
101	X85	BS	7.00000	17.00000	.	NONE	.
102	X86	LL	.	.	.	NONE	15.37963-
103	X87	LL	.	.	.	NONE	15.37963-
104	X88	LL	.	17.00000	.	NONE	.60185-
105	X89	LL	.	.	.	NONE	15.37963-
106	X810	LL	.	17.00000	.	NONE	.30556-
107	X91	LL	.	.	.	NONE	16.88889-
108	X92	LL	.	.	.	NONE	16.88889-
109	X93	LL	.	.	.	NONE	16.88889-
110	X94	LL	.	.	.	NONE	16.88889-
111	X95	LL	.	.	.	NONE	16.88889-
112	X96	BS	16.00000	17.00000	.	NONE	.
113	X97	LL	.	17.00000	.	NONE	1.37037-
114	X98	LL	.	17.00000	.	NONE	1.37037-
115	X99	LL	.	.	.	NONE	16.88889-
116	X910	LL	.	17.00000	.	NONE	.92593-
117	X101	LL	.	.	.	NONE	14.07407-
118	X102	LL	.	.	.	NONE	14.07407-
119	X103	LL	.	15.00000	.	NONE	1.02963-
120	X104	LL	.	.	.	NONE	14.07407-
121	X105	LL	.	15.00000	.	NONE	.53241-
122	X106	LL	.	.	.	NONE	14.07407-
123	X107	LL	.	.	.	NONE	14.07407-
124	X108	LL	.	15.00000	.	NONE	.37037-
125	X109	BS	12.00000	15.00000	.	NONE	.
126	X1010	LL	.	15.00000	.	NONE	.40741-

	NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
	127	X111	LL	.	.	.	NONE	11.70370-
	128	X112	LL	.	.	.	NONE	11.70370-
	129	X113	LL	.	13.00000	.	NONE	.48148-
	130	X114	LL	.	.	.	NONE	11.70370-
	131	X115	BS	3.75000	13.00000	.	NONE	.
	132	X116	LL	.	.	.	NONE	11.70370-
	133	X117	LL	.	.	.	NONE	11.70370-
	134	X118	BS	2.53571	13.00000	.	NONE	.
	135	X119	BS	5.71429	13.00000	.	NONE	.
	136	X1110	LL	.	13.00000	.	NONE	.03704-
	137	X121	LL	.	.	.	NONE	7.88889-
	138	X122	LL	.	.	.	NONE	7.88889-
	139	X123	LL	.	.	.	NONE	7.88889-
	140	X124	LL	.	9.00000	.	NONE	.50926-
	141	X125	LL	.	.	.	NONE	7.88889-
	142	X126	LL	.	.	.	NONE	7.88889-
	143	X127	BS	17.33333	9.00000	.	NONE	.
	144	X128	BS	2.66667	9.00000	.	NONE	.
	145	X129	LL	.	.	.	NONE	7.88889-
	146	X1210	LL	.	.	.	NONE	7.88889-
	147	X131	LL	.	.	.	NONE	5.88889-
	148	X132	LL	.	.	.	NONE	5.88889-
	149	X133	LL	.	.	.	NONE	5.88889-
	150	X134	LL	.	.	.	NONE	5.88889-
	151	X135	LL	.	.	.	NONE	5.88889-
	152	X136	LL	.	.	.	NONE	5.88889-
	153	X137	BS	16.00000	7.00000	.	NONE	.
	154	X138	LL	.	.	.	NONE	5.88889-
	155	X139	LL	.	.	.	NONE	5.88889-
	156	X1310	LL	.	.	.	NONE	5.88889-
	157	X141	LL	.	.	.	NONE	4.11111-
	158	X142	LL	.	.	.	NONE	4.11111-
	159	X143	LL	.	.	.	NONE	4.11111-
	160	X144	LL	.	.	.	NONE	4.11111-
	161	X145	LL	.	.	.	NONE	4.11111-
	162	X146	BS	7.83125	5.00000	.	NONE	.
	163	X147	LL	.	5.00000	.	NONE	1.33333-
	164	X148	LL	.	5.00000	.	NONE	.59259-
	165	X149	LL	.	5.00000	.	NONE	.59259-
	166	X1410	BS	.16875	5.00000	.	NONE	.
A	167	X151	LL	.	.	.	NONE	.
A	168	X152	LL	.	.	.	NONE	.
A	169	X153	LL	.	.	.	NONE	.
A	170	X154	LL	.	.	.	NONE	.
A	171	X155	LL	.	.	.	NONE	.
	172	X156	BS	2.37222	1.00000	.	NONE	.
	173	X157	LL	.	1.00000	.	NONE	1.59259-
A	174	X158	LL	.	.	.	NONE	.
A	175	X159	LL	.	.	.	NONE	.
A	176	X1510	LL	.	.	.	NONE	.

```
MPS-PTF4        CONTROL PROGRAM COMPILER - MPS/360 V2-M10
            0001                          PROGRAM
            0002                          INITIALZ
            0065                          MOVE(XDATA,'SUBS')
            0066                          MOVE(XPBNAME,'PECK1')
            0067                          MOVE(XOBJ,'VALUE')
            0068                          MOVE(XRHS,'ALOT1')
            0069                          CONVERT('SUMMARY')
            0070                          BCDOUT
            0071                          SETUP('MAX')
            0072                          PRIMAL
            0073                          SOLUTION
            0074                          EXIT
            0075                          PEND


IEC130I SYSABS   DD STATEMENT MISSING
IEC130I SYSPUNCH DD STATEMENT MISSING
IEF285I   SYS1.MPS360LP                                          PASSED
IEF285I   VOL SER NOS= MAPY   .
IEF285I   SYS74052.T115457.RV000.PECK1336.R0000001               DELETED
IEF285I   VOL SER NOS= SPOOL3.
IEF285I   SYS74052.T115457.RV000.PECK1336.R0000002               DELETED
IEF285I   VOL SER NOS= SPOOL3.
IEF285I   SYS74052.T115457.RV000.PECK1336.R0000003               DELETED
IEF285I   VOL SER NOS= SPOOL1.
IEF285I   SYS74052.T115457.RV000.PECK1336.R0000004               DELETED
IEF285I   VOL SER NOS= SPOOL2.
IEF285I   SYS74052.T115457.FV000.PECK1336.R0000005               PASSED
IEF285I   VOL SER NOS= SPOOL3.
IEF285I   SYS74052.T115457.SV000.PECK1336.R0000006               SYSOUT
IEF285I   VOL SER NOS= SPOOL1.
IEF285I   SYS74052.T115457.PV000.PECK1336.S0000007               SYSIN
IEF285I   VOL SER NOS= SPOOL2.
IEF285I   SYS74052.T115457.RV000.PECK1336.S0000007               DELETED
IEF285I   VOL SER NOS= SPOOL2.
IEF373I STEP /MPS1     / START 74052.1155
IEF374I STEP /MPS1     / STOP  74052.1156 CPU    0MIN 01.58SEC MAIN  70K LCS    0K
APPROXIMATELY-     14 SYSOUT LINES THIS STEP     *** PLEASE BLOCK ***
XXMPS2    EXEC  PGM=EXECUTOR,COND=(0,NE,MPS1),TIME=2,REGION=100K              00000090
XXSTEPLIB   DD  DSN=SYS1.MPS360LP,DISP=SHR                                    00000100
XXSYSMLCP   DD  DSNAME=*.MPS1.SYSMLCP,DISP=(OLD,DELETE)                       00000110
XXSCRATCH1  DD  UNIT=SYSDA,SPACE=(CYL,(3),,CONTIG)                            00000120
XXSCRATCH2  DD  UNIT=(SYSDA,SEP=SCRATCH1),SPACE=(CYL,(3),,CONTIG)             00000130
XXPROBFILE  DD  UNIT=SYSDA,SPACE=(CYL,(3),,CONTIG)                            00000140
XXMATRIX1   DD  UNIT=SYSDA,SPACE=(CYL,(3),,CONTIG)                            00000150
XXETA1      DD  UNIT=SYSDA,SPACE=(CYL,(3),,CONTIG)                            00000160
XXMPSCRAT   DD  UNIT=SYSDA,SPACE=(CYL,(3),,CONTIG)                            00000170
XXSYSPRINT  DD  SYSOUT=A,DCB=(RECFM=UA,BLKSIZE=133)                           00000180
//MPS2.SYSIN DD *
//
IEF236I ALLOC. FOR PECK1336 MPS2
IEF237I 235    ALLOCATED TO STEPLIB
IEF237I 234    ALLOCATED TO SYSMLCP
IEF237I 233    ALLOCATED TO SCRATCH1
IEF237I 234    ALLOCATED TO SCRATCH2
IEF237I 232    ALLOCATED TO PROBFILE
IEF237I 233    ALLOCATED TO MATRIX1
IEF237I 234    ALLOCATED TO ETA1
IEF237I 232    ALLOCATED TO MPSCRAT
IEF237I 233    ALLOCATED TO SYSPRINT
IEF237I 234    ALLOCATED TO SYSIN
```

```
MPS-PTF4            EXECUTOR.     MPS/360 V2-M10

NAME                SUBS
ROWS
 N  VALUE
 L  SUB1
 L  SUB2
 L  SUB3
 L  SUB4
 L  SUB5
 L  SUB6
 L  SUB7
 L  SUB8
 L  SUB9
 L  SUB10
 L  SUB11
 L  SUB12
 L  SUB13
 L  SUB14
 L  SUB15
 E  MIS1
 E  MIS2
 E  MIS3
 E  MIS4
 E  MIS5
 E  MIS6
 E  MIS7
 E  MIS8
 E  MIS9
 E  MIS10
COLUMNS
    X11       SUB1           1.00000
    X12       VALUE         25.00000   SUB1          1.00000
    X12       MIS2            .03000
    X13       VALUE         25.00000   SUB1          1.00000
    X13       MIS3            .02000
    X14       SUB1           1.00000
    X15       SUB1           1.00000
    X16       SUB1           1.00000
    X17       SUB1           1.00000
    X18       SUB1           1.00000
    X19       SUB1           1.00000
    X110      VALUE         25.00000   SUB1          1.00000
    X110      MIS10           .03000
    X21       SUB2           1.00000
    X22       VALUE         24.00000   SUB2          1.00000
    X22       MIS2            .04000
    X23       SUB2           1.00000
    X24       SUB2           1.00000
    X25       SUB2           1.00000
    X26       SUB2           1.00000
    X27       SUB2           1.00000
    X28       VALUE         24.00000   SUB2          1.00000
    X28       MIS8            .03000
    X29       SUB2           1.00000
    X210      VALUE         24.00000   SUB2          1.00000
```

X210	MIS10	.04000		
X31	SUB3	1.00000		
X32	VALUE	23.00000	SUB3	1.00000
X32	MIS2	.05000		
X33	SUB3	1.00000		
X34	SUB3	1.00000		
X35	SUB3	1.00000		
X36	SUB3	1.00000		
X37	SUB3	1.00000		
X38	VALUE	23.00000	SUB3	1.00000
X38	MIS8	.04000		
X39	SUB3	1.00000		
X310	VALUE	23.00000	SUB3	1.00000
X310	MIS10	.05000		
X41	SUB4	1.00000		
X42	VALUE	23.00000	SUB4	1.00000
X42	MIS2	.06000		
X43	SUB4	1.00000		
X44	SUB4	1.00000		
X45	SUB4	1.00000		
X46	SUB4	1.00000		
X47	SUB4	1.00000		
X48	VALUE	23.00000	SUB4	1.00000
X48	MIS8	.05000		
X49	SUB4	1.00000		
X410	VALUE	23.00000	SUB4	1.00000
X410	MIS10	.05000		
X51	VALUE	20.00000	SUB5	1.00000
X51	MIS1	.05000		
X52	VALUE	20.00000	SUB5	1.00000
X52	MIS2	.08000		
X53	VALUE	20.00000	SUB5	1.00000
X53	MIS3	.06000		
X54	SUB5	1.00000		
X55	SUB5	1.00000		
X56	SUB5	1.00000		
X57	SUB5	1.00000		
X58	SUB5	1.00000		
X59	SUB5	1.00000		
X510	SUB5	1.00000		
X61	VALUE	20.00000	SUB6	1.00000
X61	MIS1	.04000		
X62	VALUE	20.00000	SUB6	1.00000
X62	MIS2	.06000		
X63	VALUE	20.00000	SUB6	1.00000
X63	MIS3	.05000		
X64	SUB6	1.00000		
X65	SUB6	1.00000		
X66	SUB6	1.00000		
X67	SUB6	1.00000		
X68	SUB6	1.00000		
X69	SUB6	1.00000		
X610	SUB6	1.00000		
X71	SUB7	1.00000		

X72	SUB7	1.00000		
X73	SUB7	1.00000		
X74	VALUE	17.00000	SUB7	1.00000
X74	MIS4	.10000		
X75	VALUE	17.00000	SUB7	1.00000
X75	MIS5	.10000		
X76	SUB7	1.00000		
X77	SUB7	1.00000		
X78	VALUE	17.00000	SUB7	1.00000
X78	MIS8	.10000		
X79	SUB7	1.00000		
X710	VALUE	17.00000	SUB7	1.00000
X710	MIS10	.11000		
X81	SUB8	1.00000		
X82	SUB8	1.00000		
X83	SUB8	1.00000		
X84	VALUE	17.00000	SUB8	1.00000
X84	MIS4	.12000		
X85	VALUE	17.00000	SUB8	1.00000
X85	MIS5	.10000		
X86	SUB8	1.00000		
X87	SUB8	1.00000		
X88	VALUE	17.00000	SUB8	1.00000
X88	MIS8	.12000		
X89	SUB8	1.00000		
X810	VALUE	17.00000	SUB8	1.00000
X810	MIS10	.13000		
X91	SUB9	1.00000		
X92	SUB9	1.00000		
X93	SUB9	1.00000		
X94	SUB9	1.00000		
X95	SUB9	1.00000		
X96	VALUE	17.00000	SUB9	1.00000
X96	MIS6	.01000		
X97	VALUE	17.00000	SUB9	1.00000
X97	MIS7	.04000		
X98	VALUE	17.00000	SUB9	1.00000
X98	MIS8	.08000		
X99	SUB9	1.00000		
X910	VALUE	17.00000	SUB9	1.00000
X910	MIS10	.07000		
X101	SUB10	1.00000		
X102	SUB10	1.00000		
X103	VALUE	15.00000	SUB10	1.00000
X103	MIS3	.11000		
X104	SUB10	1.00000		
X105	VALUE	15.00000	SUB10	1.00000
X105	MIS5	.09000		
X106	SUB10	1.00000		
X107	SUB10	1.00000		
X108	VALUE	15.00000	SUB10	1.00000
X108	MIS8	.07000		
X109	VALUE	15.00000	SUB10	1.00000
X109	MIS9	.05000		

X1010	VALUE	15.00000	SUB10	1.00000
X1010	MIS10	.09000		
X111	SUB11	1.00000		
X112	SUB11	1.00000		
X113	VALUE	13.00000	SUB11	1.00000
X113	MIS3	.10000		
X114	SUB11	1.00000		
X115	VALUE	13.00000	SUB11	1.00000
X115	MIS5	.08000		
X116	SUB11	1.00000		
X117	SUB11	1.00000		
X118	VALUE	13.00000	SUB11	1.00000
X118	MIS8	.07000		
X119	VALUE	13.00000	SUB11	1.00000
X119	MIS9	.07000		
X1110	VALUE	13.00000	SUB11	1.00000
X1110	MIS10	.09000		
X121	SUB12	1.00000		
X122	SUB12	1.00000		
X123	SUB12	1.00000		
X124	VALUE	9.00000	SUB12	1.00000
X124	MIS4	.12000		
X125	SUB12	1.00000		
X126	SUB12	1.00000		
X127	VALUE	9.00000	SUB12	1.00000
X127	MIS7	.03000		
X128	VALUE	9.00000	SUB12	1.00000
X128	MIS8	.06000		
X129	SUB12	1.00000		
X1210	SUB12	1.00000		
X131	SUB13	1.00000		
X132	SUB13	1.00000		
X133	SUB13	1.00000		
X134	SUB13	1.00000		
X135	SUB13	1.00000		
X136	SUB13	1.00000		
X137	VALUE	7.00000	SUB13	1.00000
X137	MIS7	.03000		
X138	SUB13	1.00000		
X139	SUB13	1.00000		
X1310	SUB13	1.00000		
X141	SUB14	1.00000		
X142	SUB14	1.00000		
X143	SUB14	1.00000		
X144	SUB14	1.00000		
X145	SUB14	1.00000		
X146	VALUE	5.00000	SUB14	1.00000
X146	MIS6	.08000		
X147	VALUE	5.00000	SUB14	1.00000
X147	MIS7	.06000		
X148	VALUE	5.00000	SUB14	1.00000
X148	MIS8	.08000		
X149	VALUE	5.00000	SUB14	1.00000
X149	MIS9	.08000		

```
MPS-PTF4           EXECUTOR.     MPS/360 V2-M10

      X1410        VALUE           5.00000     SUB14              1.00000
      X1410        MIS10            .06000
      X151         SUB15           1.00000
      X152         SUB15           1.00000
      X153         SUB15           1.00000
      X154         SUB15           1.00000
      X155         SUB15           1.00000
      X156         VALUE           1.00000     SUB15              1.00000
      X156         MIS6             .09000
      X157         VALUE           1.00000     SUB15              1.00000
      X157         MIS7             .07000
      X158         SUB15           1.00000
      X159         SUB15           1.00000
      X1510        SUB15           1.00000
RHS
      ALOT1        SUB1            8.00000     SUB2               4.00000
      ALOT1        SUB3           32.00000     SUB4              12.00000
      ALOT1        SUB5            8.00000     SUB6              40.00000
      ALOT1        SUB7            4.00000     SUB8              12.00000
      ALOT1        SUB9           16.00000     SUB10             12.00000
      ALOT1        SUB11          12.00000     SUB12             20.00000
      ALOT1        SUB13          16.00000     SUB14              8.00000
      ALOT1        SUB15          32.00000     MIS1               1.00000
      ALOT1        MIS2            1.00000     MIS3               1.00000
      ALOT1        MIS4            1.00000     MIS5               1.00000
      ALOT1        MIS6            1.00000     MIS7               1.00000
      ALOT1        MIS8            1.00000     MIS9               1.00000
      ALOT1        MIS10           1.00000
ENDATA
```

LIST OF REFERENCES

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This thesis relates the fact that, in the past, our ASW community has placed great (and justifiable) emphasis in detection and classification of submarines, while a serious lag in tactical procedures has developed. In order to alleviate this problem, it was felt that a systematic approach be taken which utilizes the principles of Operations Research.

By examining submarine warfare from the viewpoint of the Soviet Union, a resource allocation problem has been devised which compares the various

submarine classes and the possible mission areas in which they may be assigned. Characteristics and available numbers of submarines were estimated, and the resulting allocation of forces was determined.

Although the analysis presented was based on hypothesized data, the strength in this approach lies in its flexibility and a wide range of applications. These features have been presented in Section III.

Thesis 148797
P319 Peck
c.1
A systematic approach toward developing ASW tactics based on plausible Soviet resource allocation.