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## A Man-Machine Competitive Game: A Naval Duel

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## A Man-Machine Competitive Game: A Naval Duel

### Abstract

The research reported here is the development of a man-machine game in which the competitors are the captain of a submarine and the commander of an opposing task force. This naval game has been implemented and tested in the Problem Solving Facility of the University of Pennsylvania under Contract NOnr 551(48) sponsored by the Methodology Division, Office of Naval Research.

The broad objective of this research has been to experiment with and develop a man-machine framework in which an executive, scientist or engineer may employ strategies and tactics in an operational environment.

A complete functional description of the game will be given in this report. This chapter provides an overview of the game and cites its salient characteristics. Chapter 2 presents the game through a play-by-play record of one competitor in an actual duel. Chapter 3 presents the various aspects of the Problem Solving methodology and developed tactics by means of three annotated duels. This also illustrates the versatility of the game and demonstrates the competitors' capability to interact with the computer. Chapter 4 summarizes our research to date and lists planned refinements to the game. Additional documentation of the game structure is provided in the appendices.

### Comments

University of Pennsylvania Department of Computer and Information Science Technical Report No. MS-CIS-68-34.

University of Pennsylvania  
THE MOORE SCHOOL OF ELECTRICAL ENGINEERING  
Philadelphia, Pennsylvania 19104

TECHNICAL REPORT

A MAN-MACHINE COMPETITIVE GAME  
A NAVAL DUEL

May 1968

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Bruce E. Lull  
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Noah S. Prywes

Prepared for the  
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Methodology Division  
Washington, D.C. 20360

under

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A MAN-MACHINE COMPETITIVE GAME -  
A NAVAL DUEL

SUMMARY AND CONCLUSIONS

The work reported herein concerns a game whereby two competing players are given aid interactively by a large scale computer. A naval war game is used as the vehicle in this research, the primary objective of which is to develop an understanding and a methodology using on-line computers. By using the game's environment, experiments with methods for interactive and real-time communications between user and computer in complex Problem Solving are demonstrated and analyzed. It is recommended that the Navy take note of this new methodology which could have potentially great influence on the development of tactics, the training of officers and the development of integrated control systems for naval vessels.

This research demonstrates how a user defines information modules, manipulates them and selectively uses them as building blocks first for larger modules and ultimately for the solution of a problem. The computer is used as a repository for all data accrued in the game; this accumulated information is always available to a player. Because the game uses an on-line computer system to simulate the real life environment, the players can request computer computations at any time and expect responses almost immediately.

While the primary purpose of this research has been towards the development of a Problem Solving methodology, one is readily impressed with the impact on applications in several other areas of direct interest to the Navy. In the man machine game environment, new tactics and strategies may be developed, recorded, analyzed and evaluated. Because of these capabilities, the game can also serve for training of commanding officers. Finally, the computer system serves the player by performing the functions of the ship's

officers' staff while simulating the motion of the vessel. Therefore, this new methodology can provide insight into the development of integrated control systems in which a commanding officer could use the computer system to obtain information and make decisions in an operational environment. The methodology is described in this report through the annotated record and explanations of several illustrative games.



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A MAN-MACHINE COMPETITIVE GAME -  
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1. INTRODUCTION

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Appendix A reviews our experience in Problem Solving research. Appendix B provides information on the equipment configuration. Appendices C and D document the data structure and function subprograms in the game, respectively.

1.1 Description of the Game

The game is played by two competitors, located at remote consoles, who each interact with the computer by controlling the movements of his assigned

vessel and the use of its equipment from his console.

The game is begun by the placing of the competitors' vessels within passive sonar range of each other and the assignment of goals to each player. The attainment or lack of attainment of the goals of the players determines the winner. Typical goals are cited in Fig. 1.1.

Player	Possible Goals
Submarine Captain	<ol style="list-style-type: none"><li>1. Attack the enemy task force.</li><li>2. Keep the task force under surveillance.</li><li>3. Penetrate the barrier defended by the task force.</li><li>4. Patrol an area and attack any detected enemy vessels.</li></ol>
Task Force Commander	<ol style="list-style-type: none"><li>1. Proceed to a destination, evading encountered submarines with minimal fuel expenditure.</li><li>2. Attack the enemy submarine.</li><li>3. Blockade a port.</li></ol>

Figure 1.1 Typical Goals of the Competitors

If the goal of the submarine is to attack the task force, the submariner attempts to locate the task force and determine its speed and course so that an interception course can be found. The task force naturally attempts to keep the submarine under surveillance, and, depending on its goal, either to evade or attack the submarine.

If the goal of the task force is to evade the submarine, the task force maneuvers to take advantage of its greater speed in evading a detected submarine. However if the submarine has gone undetected or has been erroneously localized, the task force may still be vulnerable.

Each player controls his vessel and its equipment by specifying commands and queries at his console. The computer system accepts such orders, then takes the required action in real-time.

## 1.2 Game Functions

To attain a high degree of reality, the game is designed so that a player has available functions which can act as various members of his crew. For example, the computer system is able to accept orders from a player and alternately assume the roles of navigator, sonar evaluator or executive officer. Seven functions were sufficient to specify the kernel of the prototype game (see Fig. 1.4).

A player at a console gives a command by referencing a function in the following manner:

FUNCTION NAME/ITEM DESCRIPTION/A/B/.../Z,

where A, B, ..., Z are input data. The corresponding computer subprogram then processes the specified data and transmits results to the console and to secondary memory, when required. Thus a function operates on both information in a designated item (a block of information stored in secondary memory) and other data specified in the statement. The data flow in a typical function subprogram is described in Fig. 1.2. Figure 1.4 lists the functions available to a player and Fig. 1.3 lists the types of items which the function may reference.

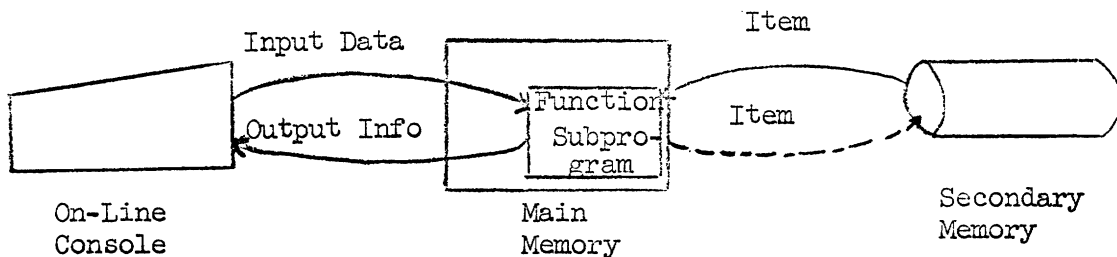


Figure 1.2 Data Flow in a Typical Function Subprogram

Type of Item	Contents
OWN	Information about a player's vessel, its equipment and its movements.
SONAR	A collection of sonar readings made by a player.
ESTO	An estimate of an opponent's movements.

Figure 1.3 Types of Items Referenced by a Function

Function Definition	Function Name	No. of Args.	Type of	
			Function	Arguments
Set Sailing Plan	SETSP	$\geq 3$	Command	OWN item & velocity vectors
Use Sensor	USESIN	$\geq 2$	Command	SONAR item & time specifications
Estimate Opponent	ESTOP	2	Command	SONAR item & ESTO item
Position	POS	$\geq 2$	Query	OWN or ESTO item & time specifications
Range of Opponent	RANGE	$\geq 2$	Query	OWN item & ESTO item & time specifications
Find Interception Course	INTER	2	Query	ESTO item & speed
Find Opponent's Interception Course	OPINT	2	Query	ESTO item & speed

Figure 1.4 Table of Player Functions

### 1.3 Salient Features of the Game

The game was designed with both realism and the human player as foremost considerations. Several features which enhance realism and/or facilitate the play of the game are cited in this section.

The game simulates the real-life environment. That is, the game simulates the motions of the various units under the control of a clock. Thus the players must meet "action deadlines" as in the real-life environment.

The game is played with an on-line real-time system. "On-line" concerns the use of remote equipment through which a player communicates with a central computer. "Real-time" relates to time-critical variables which demand immediate, current, fact-based decisions. Thus a player, located at a remote console, can communicate with the central computer and receive responses sufficiently rapid to make subsequent decisions before the opportunity to make any decision at all is lost. The computer system which provides this environment has been described in a project report titled, A Problem Solving Facility.<sup>[5]</sup>

The game uses the computer as a repository for all accumulated information. The nucleus for such a growing system is the MULTILIST system in which a block of information (called an item) may be stored in a large secondary memory and retrieved by reference to its associated keywords.<sup>[1]</sup> Thus a player can recall relevant past experience in resolving dilemmas in the game.

The game has a minimal set of operators which are specified in a standardized functional format. Thus a player has available a compact set of functions which accept orders or queries, then act as various members of his crew. The language in which these functions are specified has been described in a project report titled, MULTILANG - An Executive System for Real-Time Problem Solving.<sup>[4]</sup>

The game is modular so that changes in its structure are facilitated.

Thus, alterations may be made by simply modifying or replacing logical components of the game.

The value of these features may be demonstrated by summarizing their contributions:

conciseness - all requests for computer response may be expressed  
in a mnemonic functional form;

immediacy - requests of the computer receive response within seconds  
of the completion of the required computations, most often  
before "action deadlines" occur;

simultaneity - since both players use the computer at essentially  
the same time, the game is played interactively;

growth - accumulated knowledge is always available to both players  
and to a referee;

modularity - refinements or extensions to the game are easy to incorporate.

We have now introduced the general structure and cited outstanding features of the game. We complete the outline of the implemented game in the next chapter by detailing the game-playing scheme of one competitor in a specific duel.

## 2. A COMPETITOR'S PLAY

The real-time interaction between the computer and the player, as well as the overall playing of the game, can most easily be understood from an example. We shall assume that the submarine and the task force are both patrolling in the North Atlantic. The game now limits the task force to be only one ship but the game has been designed so that extensions to include a larger task force fall within the general structure and so are relatively simple to add.

The game is started by fixing the initial position of each vessel using the function START:

```
START/RED+OWN/=40.12/=-30/WHITE+OWN/=40.0/=-30  
INITIAL POSITION HAS BEEN STORED FOR TIME = 135938
```

Each side is given a name. We have called the submarine RED and the task force WHITE. The first item specified by START (see Fig. 2.1) is the OWN item of the submarine and this item is initialized so that the position of the SS is  $40.12^{\circ}$  N,  $30^{\circ}$  W. This sequence may be repeated if it is desired to set both positions at once. We have thus set the position of the task force to be  $40^{\circ}$  N,  $30^{\circ}$  W. The task force and submarine are 7.2 miles apart, well within sonar range of each other. The submarine's goal is to keep an area under surveillance and the goal of the task force is to attack any detected enemy submarine. For this purpose, we have set the task force to be a destroyer.

We shall follow the activities of the destroyer captain. As each function is used, reference to Fig. 2.1 will aid in understanding what is happening. Initially, the destroyer is in a weaving pattern as it patrols a certain distance from the submarine:

```
SETSP/WHITE+OWN/=15/=-30/=2/=15/=30/=4/=15/=-30  
THE SAILING PLAN HAS BEEN STARTED TIME= 135955
```

Function Name	Item	Item	Data
START	OWN	---	Initial latitude/initial longitude
SETSP	OWN	---	a) speed/course/duration b) speed/course/depth/duration
USES	SONAR	---	a) time1/time2/time3... b) time interval between readings/ number of readings desired.
ESTOP	SONAR	ESTO	---
INTER	ESTO	---	desired speed of interception
OPINT	ESTO	---	assumed speed that opponent will use to intercept
POS	OWN or ESTO	---	time1/time2/time3...
RANGE	OWN or ESTO	OWN or ESTO	a) no data needed b) time range is desired c) first time range is desired/ time interval between requests/ number of requests

Figure 2.1 Format and Description of Player Functions

SETSP applied to WHITE sets the sailing plan of the DD. The initial speed is 15 Knots, course is  $-30^{\circ}$  (or  $330^{\circ}$ ) and the duration is two minutes. This is specified by the first three numeric arguments: =15/=-30/=2. The sequence of commands can be repeated as many times as is desired. The full command sets up the patrol as shown in Fig. 2.2. The final sequence does not need any time duration. If this duration is missing, the last speed and course is maintained until further instructions are received.

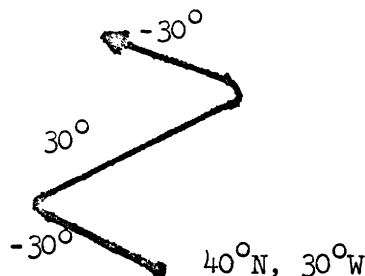


Figure 2.2 Patrol Course of Destroyer Going at 15 Knots



The destroyer captain now uses USESN to start taking sonar readings:

```
-----  
      USESN/WHITE+ACT1+STEP/=1/=5  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES  
-----  
      USESN/WHITE+ACT2/=1404/=1405/=1406/=1407/=1408  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES  
-----  
      USESN/WHITE+ACT3/=1407/=1408/=1409/=1410/=1411  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES  
-----  
      USESN/WHITE+ACT4/=1410/=1411/=1412/=1413/=1414  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES  
-----  
      USESN/WHITE+ACT5/=1413/=1414/=1415/=1416/=1417  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES  
-----  
      USESN/WHITE+ACT6/=1416/=1417/=1418/=1419/=1420  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES  
-----  
      USESN/WHITE+ACT7/=1419/=1420/=1421/=1422/=1423  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES  
-----
```

Each command calls for the taking of sonar readings at the specified times and putting the results into a SONAR item. The first command requests five readings at intervals of one minute. The readings are to be started immediately and the data is to be stored in item ACT1. The next command requests five readings between 14:04 and 14:08 with the data going into item ACT2. Similarly, readings are to be taken and stored until 14:23.

WHITE now requests an estimate of the enemy's speed and course using the first set of sonar readings:

```
-----  
      ESTOP/ACT1/SUB1  
INCOMPLETE SENSOR READINGS TAKEN  
      BASED ON +0003. READINGS BETWEEN 140015 AND 140215  
      OPPONENT GOING +0005. KNOTS ON COURSE -0000.  
-----
```

The function ESTOP uses the SONAR item ACT1 to estimate the opponent's position, speed and course. This information is then stored in the newly created item

SUB1. Because ESTOP uses all the sonar readings in any SONAR item, the sonar readings are grouped together in separate items. In this way, the opponent's speed and course estimates may be based on small time intervals. The commands to take sonar readings therefore order the creation of a new SONAR item for every few minutes of data, as shown above. Estimates of the range and true bearing between the DD and SS are then obtained using the function RANGE.

---

RANGE/WHITE+OWN/SUB1  
RANGE = +0006.660000 BEARING = +0002. AT TIME = 140328

---

The results are that the range is 6.6 miles and the true bearing from the destroyer to the submarine is  $2^{\circ}$ . WHITE now considers attacking and uses INTER to determine his intercept course if he goes at 30 Knots, which is his maximum speed:

---

INTER/SUB1/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0016. MINUTES AT 141925 CRSE=+0002.

---

He decides to attack and orders a change of course:

---

SETSP/WHITE+OWN/=30/=2  
THE SAILING PLAN HAS BEEN STARTED TIME= 140436

---

This cancels the patrol at 14:04:36 and starts a turn towards an intercept course of  $2^{\circ}$ .

The destroyer captain then checks on the position of the submarine as he closes in:

ESTOP/ACT2/SUB2  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 140400 AND 140600  
OPPONENT GOING +0005. KNOTS ON COURSE +0002.

INTER/SUB2/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0014. MINUTES AT 142028 CRSE=+0001.

RANGE/WHITE+OWN/SUB2  
RANGE = +0005.670000 BEARING = +0000. AT TIME = 140648

ESTOP/ACT3/SUB3  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 140700 AND 140900  
OPPONENT GOING +0005. KNOTS ON COURSE +0004.

INTER/SUB3/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0011. MINUTES AT 142028 CRSE=+0001.

RANGE/WHITE+OWN/SUB3  
RANGE = +0004.500000 BEARING = +0000. AT TIME = 140936

ESTOP/ACT4/SUB4  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 141000 AND 141200  
OPPONENT GOING +0006. KNOTS ON COURSE +0003.

INTER/SUB4/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0008. MINUTES AT 142106 CRSE=+0001.

RANGE/WHITE+OWN/SUB4  
RANGE = +0003.170000 BEARING = +0000. AT TIME = 141257

This information confirms his earlier estimate of the submarine's position and shows that the submarine is still going approximately 5 Knots in the same general direction.

Figure 2.3 shows how accurate WHITE's estimates are. They have been very good up to this time as the submarine has been travelling at almost the same speed and course for over 10 minutes. The line shows the submarine's course as a function of time. The dots show WHITE's estimates of the sub-

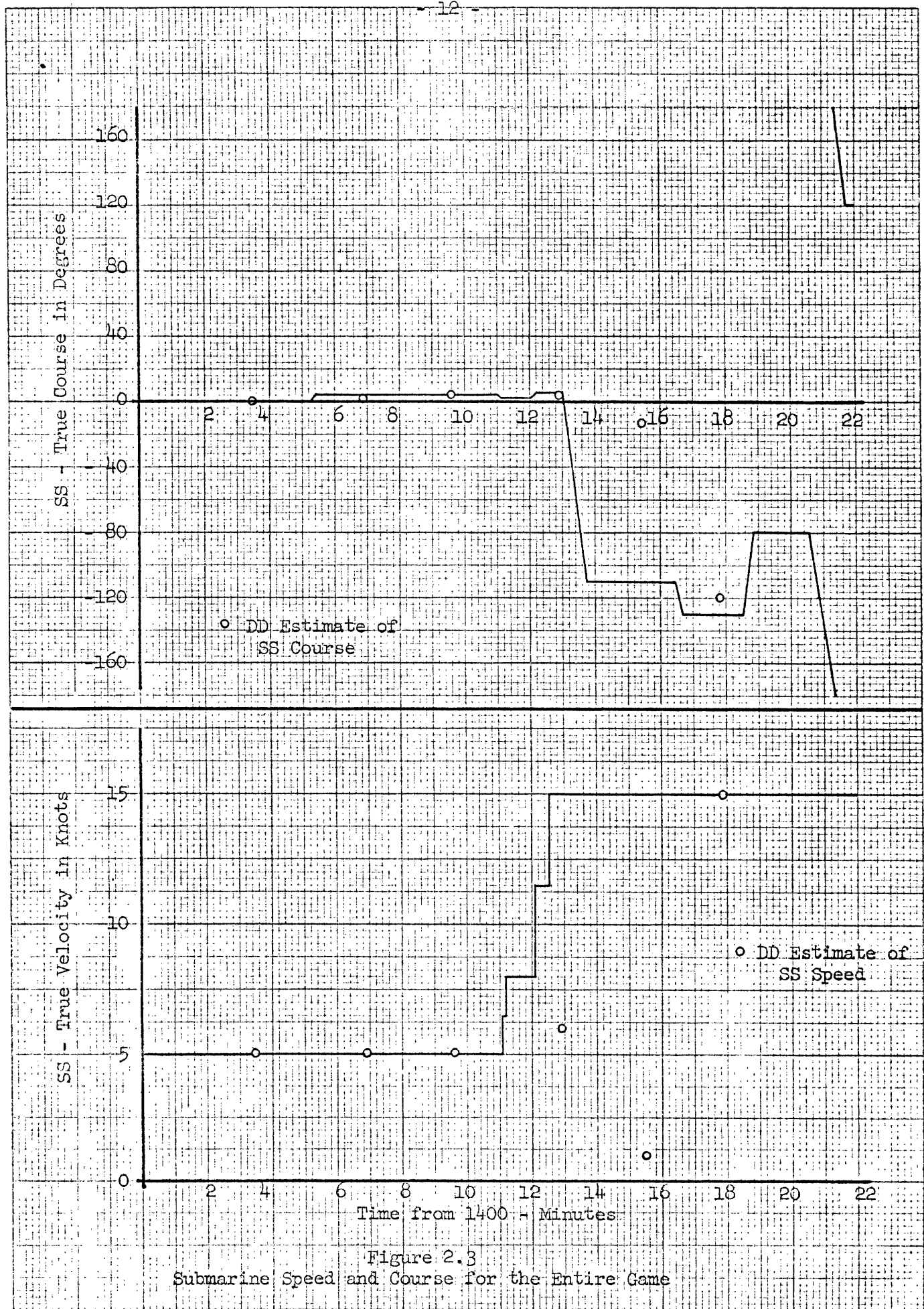


Figure 2.3  
Submarine Speed and Course for the Entire Game

marine's course at those particular times. The estimates are not as good towards the end of the game when the submarine is maneuvering and there is less time to gather information. The destroyer captain makes a minor course change at 14:10:51 to conform to his latest data:

---

SETSP/WHITE+OWN/=30/=1  
THE SAILING PLAN HAS BEEN STARTED TIME= 141051

---

He also notices that the range is steadily decreasing so that in a few more minutes he will be within weapon range of the submarine. The range between the destroyer and submarine for the entire game is shown in Fig. 2.4.

At this point, it should be mentioned that the game is still without any sophisticated weapon models. One weapon is allowed - a torpedo whose range is 2 1/4 miles and which travels at 45 Knots.

Meanwhile, however, the submarine captain has been waiting for the destroyer to get fairly close. His latest information tells him that the destroyer is rapidly closing in:

---

RANGE/RED+OWN/DD2/=1405/=2/=5		
RANGE = +0006.250000	BEARING = -0178.	AT TIME = 140500
RANGE = +0005.590000	BEARING = -0179.	AT TIME = 140700
RANGE = +0004.920000	BEARING = +0179.	AT TIME = 140900
RANGE = +0004.260000	BEARING = +0178.	AT TIME = 141100
RANGE = +0003.600000	BEARING = +0177.	AT TIME = 141300

---

This call to the function RANGE uses the ESTO item DD<sup>2</sup> which RED has previously created. It asks for the range in intervals of two minutes starting at 14:05. RED also has the probable time the destroyer will intercept him:

---

OPINT/RED+DD2/=30  
IF RIVAL TRAVELS AT +0030. KNOTS,  
INTERCEPTION IN +0013. MINUTES AT 142040 CRSE=+0001.

---

The function OPINT gives the submarine captain the intercept course the destroyer will take if he increases his speed to 30 Knots while the submarine continues at his present sailing plan. The submarine captain now believes

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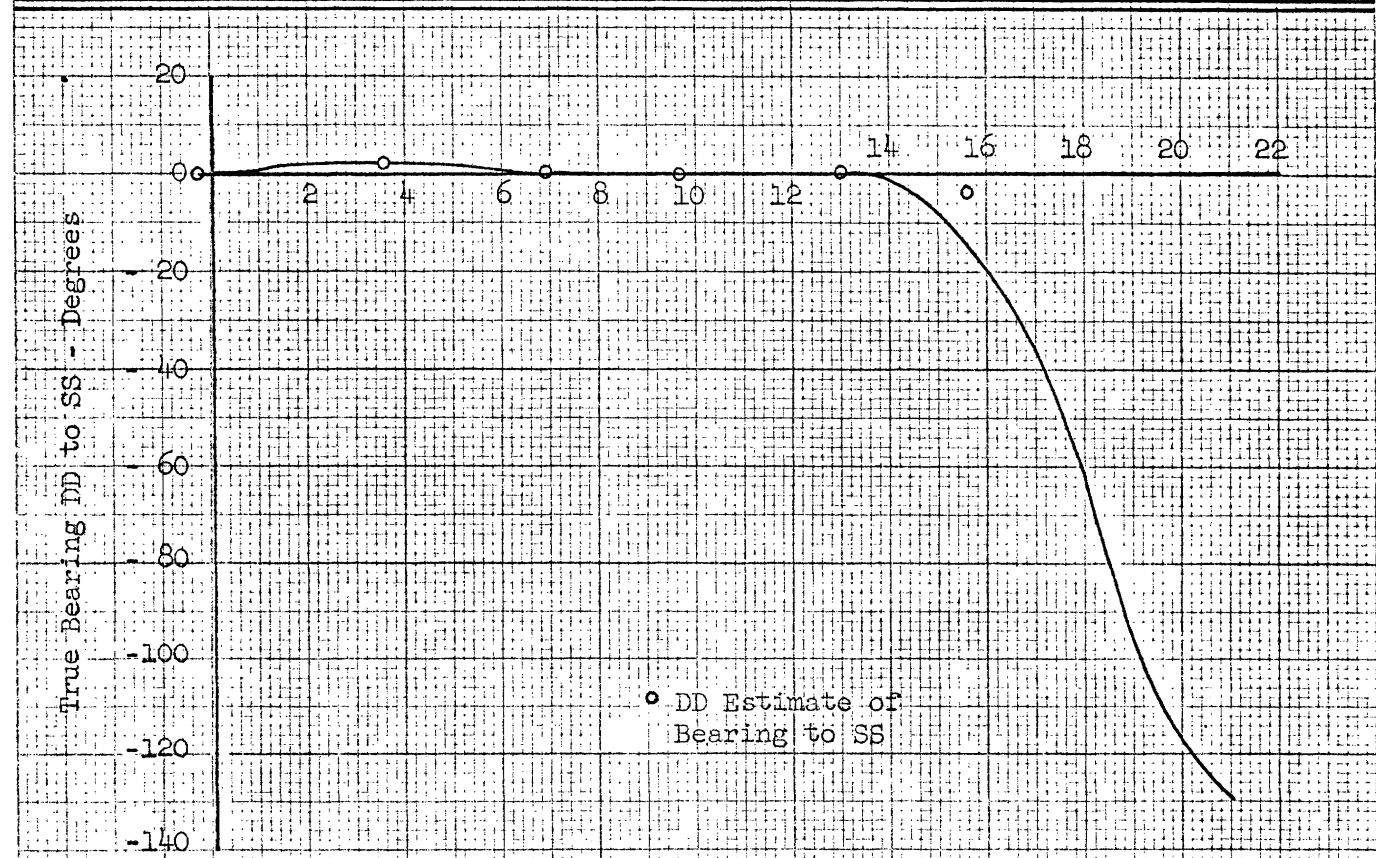
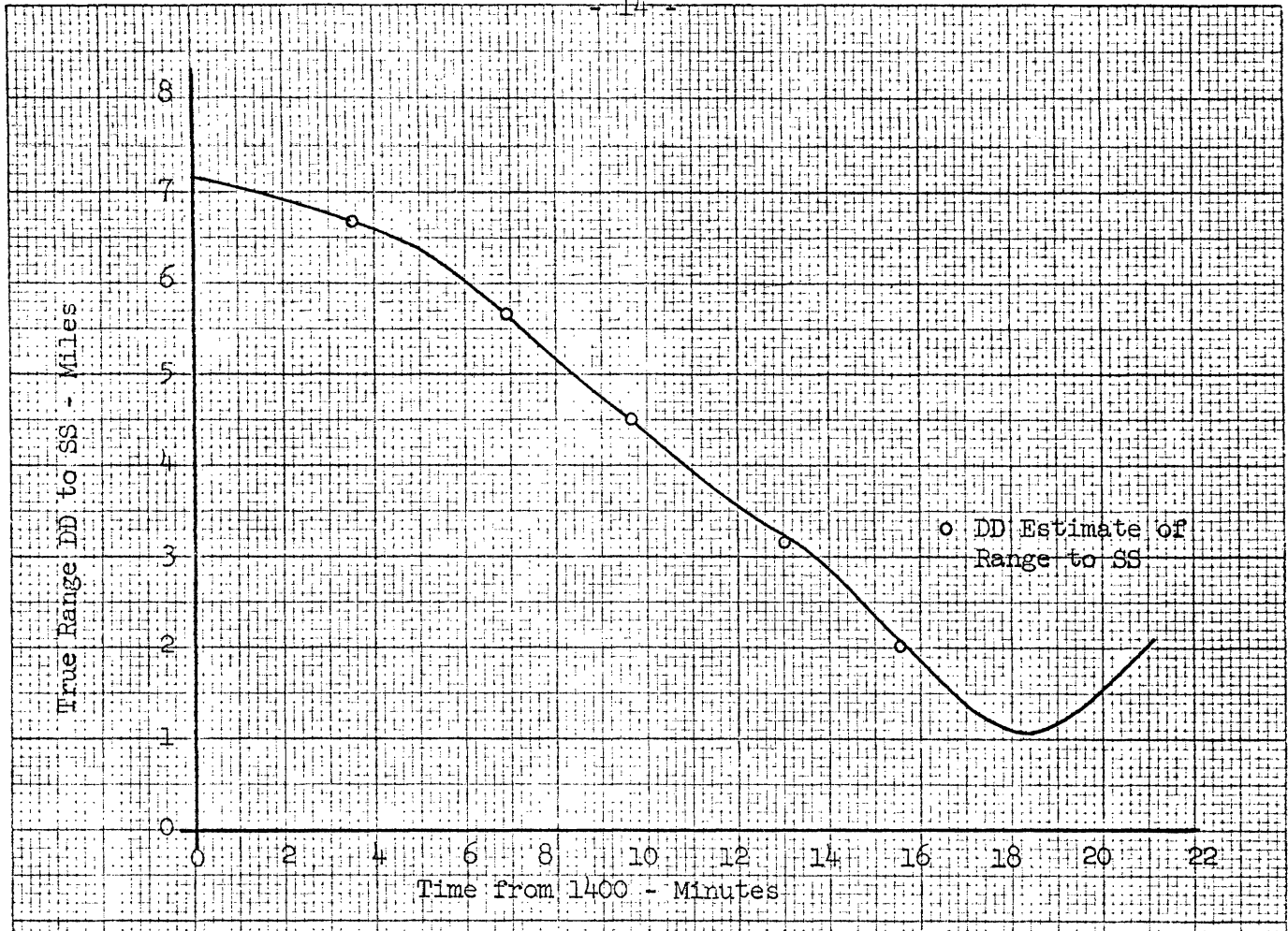


Figure 2.4  
Range and Bearing from the Destroyer to the Submarine  
for the Entire Game

that the destroyer is maintaining 25 Knots:

---

ESTOP/RED+SON2/DD2  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0004. READINGS BETWEEN 140400 AND 140700  
OPPONENT GOING +0025. KNOTS ON COURSE +0006.

---

Based on this information, the submarine captain starts a maneuver at 14:11 and then continues to maneuver as he receives more sonar readings:

---

SETSP/RED+OWN/=8/=2/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 141103

---

SETSP/RED+OWN/=15/=6/=100/=1/=15/=-110/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 141202

---

SETSP/RED+OWN/=15/=-130/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 141628

---

SETSP/RED+OWN/=15/=-100/=100/=2/=15/=120/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 141836

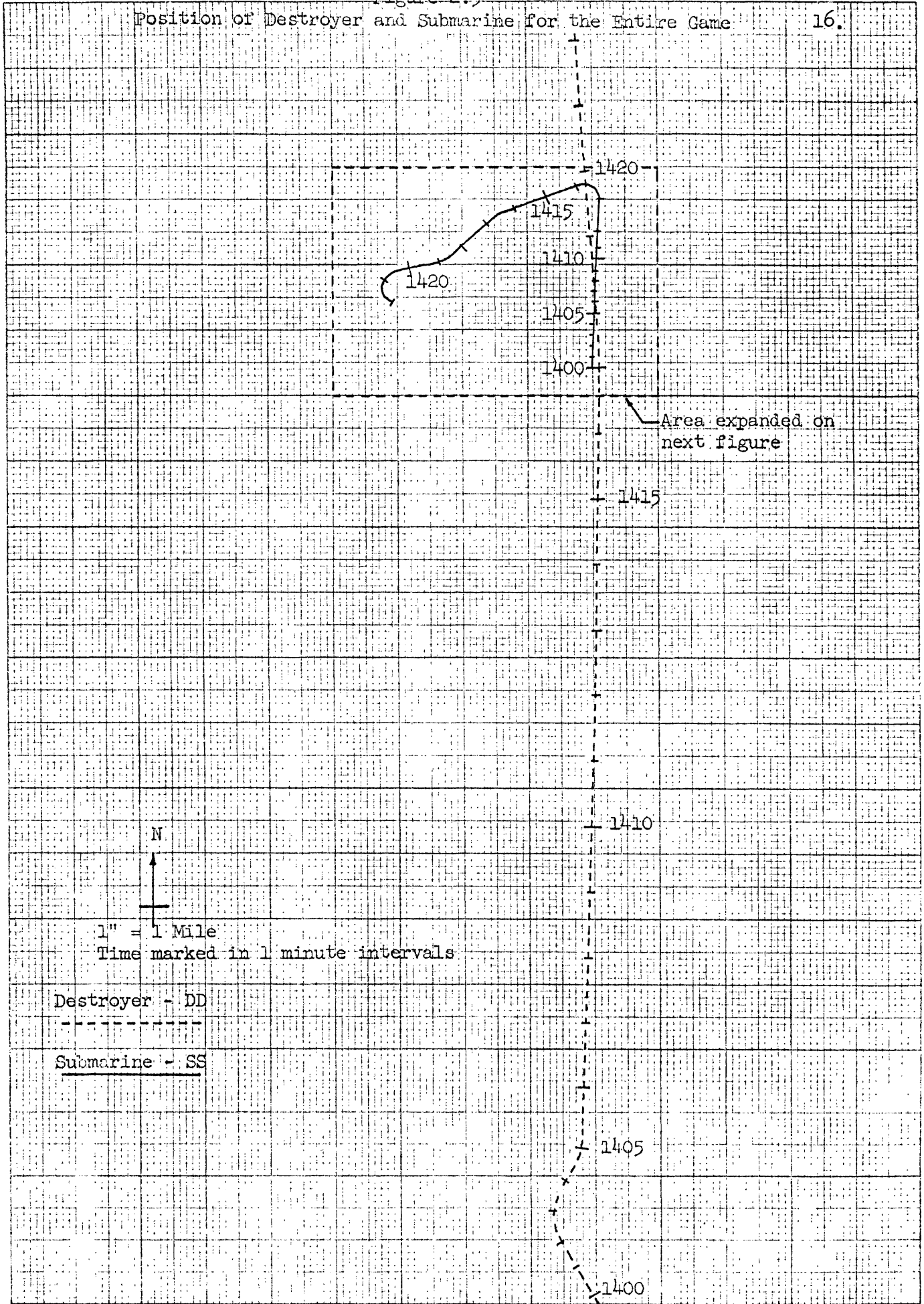
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The functions that RED uses during the period of time immediately before starting his maneuver as well as all requests for information and all commands for the entire game are listed in Sect. 3 in the order of their execution and so will not be repeated here. An overall flow of the game can be seen in Fig. 2.5. This shows the destroyer closing in and the maneuver made by the submarine in its attempt to mislead its attacker.

The destroyer captain now requests what he hopes will be his final estimate of the submarine and one which will give him enough information to launch a weapon:

Figure 2.5

Position of Destroyer and Submarine for the Entire Game



MADE IN U. S. A.

20 X 20 PER INCH



ESTOP/ACT5/SUB5  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 141300 AND 141500  
OPPONENT GOING +0001. KNOTS ON COURSE -0013.  
INTER/SUB5/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0004. MINUTES AT 141947 CRSE=-0004.  
INTER/SUB5/=45  
IF YOU TRAVEL AT +0045. KNOTS,  
INTERCEPTION IN +0003. MINUTES AT 141821 CRSE=-0004.  
RANGE/WHITE+OWN/SUB5  
RANGE = +0002.000000 BEARING = -0004. AT TIME = 141539

He notices that the submarine is only two miles away, just within weapon range but that his course has changed and so he may very well be turning. Finally a speed of one knot looks very suspicious for if the submarine is actually trying to evade the destroyer he would be going faster. The use of INTER with a speed of 45 tells WHITE the proper course at which to fire a torpedo, since the torpedo travels at 45 Knots. WHITE decides that his information is too unreliable and so makes a slight course change while waiting for more information.

SETSP/WHITE+OWN/=30/=-4  
THE SAILING PLAN HAS BEEN STARTED TIME= 141655  
ESTOP/ACT6/SUB6  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 141600 AND 141700  
OPPONENT GOING +0015. KNOTS ON COURSE -0119.  
INTER/SUB6/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0004. MINUTES AT 142158 CRSE=-0093.  
INTER/SUB6/=45  
IF YOU TRAVEL AT +0045. KNOTS,  
INTERCEPTION IN +0002. MINUTES AT 142029 CRSE=-0090.

This latest data confirms that the submarine is turning and has increased its speed. The destroyer commander is not exactly sure where the submarine is but notices that it is still within weapon range and decides to fire a torpedo before the submarine maneuvers any longer. Based on his information he fires the torpedo at  $-90^{\circ}$  so that it should explode at 14:20:29.

To learn if the submarine has been hit, a referee executes:

RANGE/RED+OWN/SUB6/=1418/=1/=5						
RANGE =	+0000.050000	BEARING =	-0029.	AT TIME =	141800	
RANGE =	+0000.060000	BEARING =	-0032.	AT TIME =	141900	
RANGE =	+0000.030000	BEARING =	+0179.	AT TIME =	142000	
RANGE =	+0000.060000	BEARING =	+0172.	AT TIME =	142100	←
RANGE =	+0000.340000	BEARING =	-0090.	AT TIME =	142200	
POS/SUB6/=1418/=1419/=1420/=1421						
PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
0080+	141800	+0040.14	-0030.02	014.7	-0119.04	+0000.
0080+	141900	+0040.13	-0030.03	014.7	-0119.04	+0000.
0080+	142000	+0040.13	-0030.03	014.7	-0119.04	+0000.
0080+	142100	+0040.13	-0030.04	014.7	-0119.04	+0000.

This information determines the accuracy of WHITE's estimate of his opponent as recorded in SUB6 and also tells us whether the submarine was hit because the torpedo trajectory intersects the estimated course given in SUB6 at 14:20:29. At the time of this intersection, the torpedo is less than 0.1 mile from the submarine. Since our model specifies a lethal radius for torpedoes of 0.1 mile, we conclude that the submarine has been sunk. From Fig. 2.6 it can be concluded that the submarine's maneuver, started at 14:18:36, actually hurt the submarine. Instead of turning right at this time, the submarine captain should have made a sharp left turn as indeed he intended to do two minutes later. This is too late and the submarine is hit just before it starts to turn.

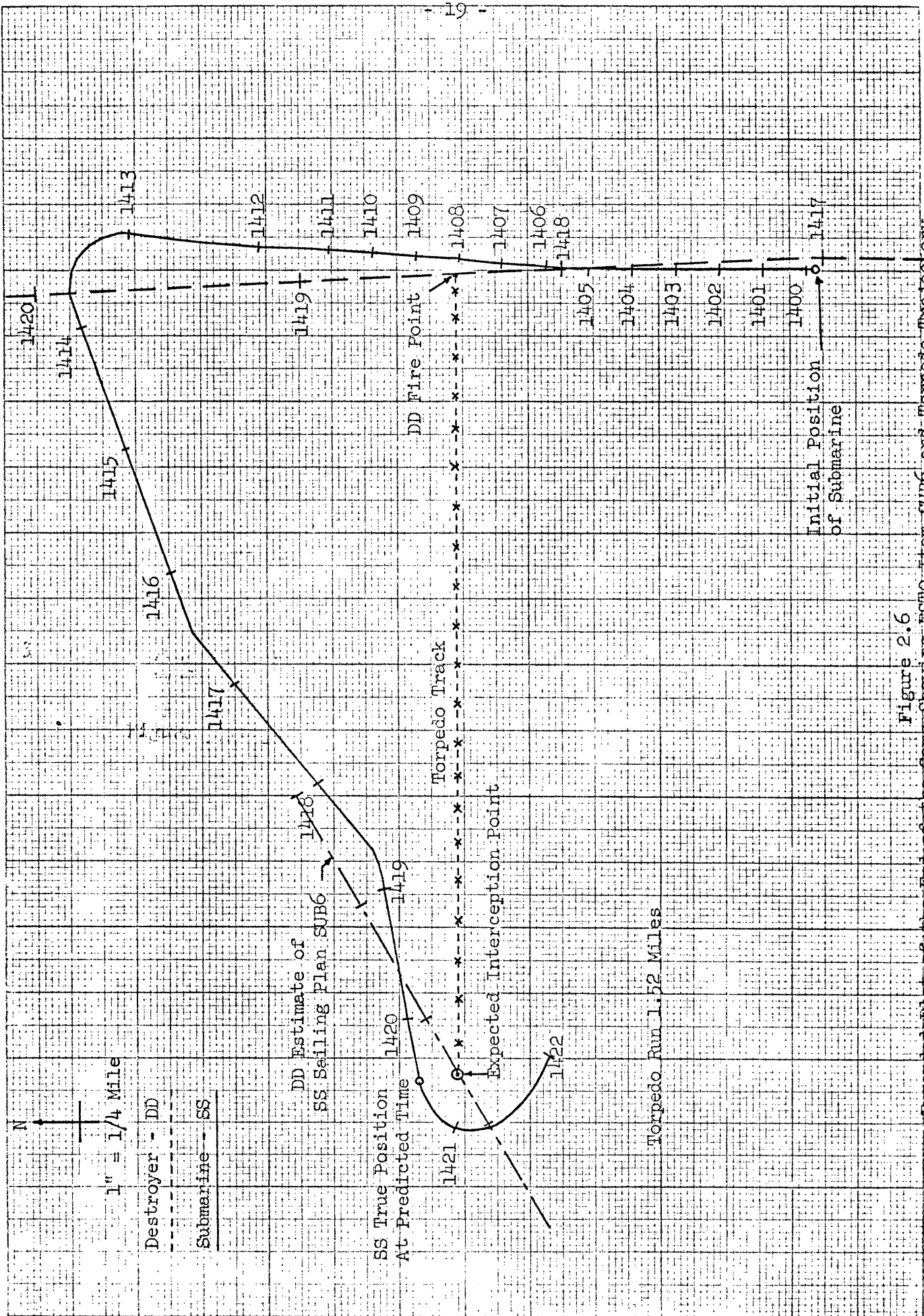


Figure 2.6

Expanded Plot of the End of the Game Showing ESDO Item SUB6 and Torpedo Trajectory

Now that the game is over, the position of both players are recorded for the entire game and thus the game can be reconstructed and analyzed. The results are listed in Sect. 3 and summarized in Figures 2.5 and 2.6.

### 3. DOCUMENTED GAMES

We now give a complete description of three games. The description consists of:

- a) the initial position and sailing plan of both players
- b) every command and query made by the task force commander
- c) every command and query made by the submarine captain
- d) functions used by the referee

The referee functions summarize the sailing history of both ships and determine the success or failure of every weapon firing. The goals of each player for these games are given in Fig. 3.1.

<u>Game</u>	<u>Task Force</u>	<u>Submarine</u>
1	Attack any detected enemy submarine	Keep the task force under surveillance.
2	Attack any detected enemy submarine	Attack any detected enemy task force.
3	Proceed to a destination evading all enemy vessels	Attack any detected enemy task force.

Figure 3.1 Goals of Both Players for Each of the Documented Games

#### 3.1 Game One

The assigned goals in Game One are:

Destroyer captain - attack any detected enemy submarine

Submarine captain - keep the task force under surveillance.

This game has been discussed in some detail in Sect. 2.2 and its complete annotated documentation follows:

<u>Functions</u>	<u>Page Number</u>
Initial Positions and Sailing Plans of Both Players	23
Commands and Queries Made By the Destroyer Captain	24
Commands and Queries Made By the Submarine Captain	29
Functions Used By the Referee	34

Initial Positions and Sailing Plans of Both Players

---

INTLZ  
INTLZ WAS ENTERED

---

The game is initialized.

---

START/RED+OWN/=40.12/=-30/WHITE+OWN/=40.0/=-30  
INITIAL POSITION HAS BEEN STORED FOR TIME = 135938

---

Initial positions are set:  
SS: 40.12° N, 30° W  
DD: 40° N, 30° W

---

SETSP/RED+OWN/=5/=0/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 135949

---

SS sets initial sailing plan

<u>Speed</u>	<u>Course</u>	<u>Depth</u>	<u>Duration</u>
5 Knots	0°	100 ft.	Unspecified

---

SETSP/WHITE+OWN/=15/=-30/=2/=15/=30/=4/=15/=-30  
THE SAILING PLAN HAS BEEN STARTED TIME= 135955

---

DD sets initial sailing plan

<u>Speed</u>	<u>Course</u>	<u>Duration</u>
15 Knots	-30° (330°)	2 min.
15	30°	4
15	-30°	Unspecified

Commands and Queries Made by the Destroyer Captain

---

USES<sub>N</sub>/WHITE+ACT1+STEP/=1/=5  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD orders five sonar readings to be taken at one minute intervals, starting immediately. Results are to be stored in ACT1.

---

USES<sub>N</sub>/WHITE+ACT2/=1404/=1405/=1406/=1407/=1408  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Take sonar readings at indicated times, between 14:04 and 14:08. Store results in ACT2.

---

USES<sub>N</sub>/WHITE+ACT3/=1407/=1408/=1409/=1410/=1411  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Take sonar readings at indicated times. Store results in ACT3.

---

USES<sub>N</sub>/WHITE+ACT4/=1410/=1411/=1412/=1413/=1414  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Store readings for times 14:10-14:14 in ACT4.

---

USES<sub>N</sub>/WHITE+ACT5/=1413/=1414/=1415/=1416/=1417  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Readings between 14:13 and 14:17 go into ACT5.

---

USES<sub>N</sub>/WHITE+ACT6/=1416/=1417/=1418/=1419/=1420  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Store readings for times 14:16-14:20 in ACT6.

---

USES<sub>N</sub>/WHITE+ACT7/=1419/=1420/=1421/=1422/=1423  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Store readings for times 14:19-14:23 in ACT7.



---

ESTOP/ACT1/SUB1  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 140015 AND 140215  
OPPONENT GOING +0005. KNOTS ON COURSE -0000.

---

DD: Obtains first estimate of SS speed and course, based  
on SONAR item ACT1. Results go into ESTO item SUB1.

---

INTER/SUB1/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0016. MINUTES AT 141925 CRSE=+0002.

---

DD: If DD travels at 30 Knots, is an interception of SS  
possible? Use data in ESTO item SUB1.

---

RANGE/WHITE+OWN/SUB1  
RANGE = +0006.660000 BEARING = +0002. AT TIME = 140328

---

DD: Find present range and bearing using item SUB1.

---

SETSP/WHITE+OWN/=30/=2  
THE SAILING PLAN HAS BEEN STARTED TIME= 140436

---

DD: Set new sailing plan to attack SS.

---

ESTOP/ACT2/SUB2  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 140400 AND 140600  
OPPONENT GOING +0005. KNOTS ON COURSE +0002.

---

DD: Obtain new estimate of SS speed and course using  
sonar readings in ACT2.

---

INTER/SUB2/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0014. MINUTES AT 142028 CRSE=+0001.

---

DD: Find new intercept course using estimate in ESTO item  
SUB2.

---

RANGE/WHITE+OWN/SUB2  
RANGE = +0005.670000 BEARING = +0000. AT TIME = 140648

---

DD: Find present estimated range and bearing using ESTO item  
SUB2.

---

ESTOP/ACT3/SUB3  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 140700 AND 140900  
OPPONENT GOING +0005. KNOTS ON COURSE +0004.

---

DD: Using SONAR item ACT3, find latest estimate of SS and  
create new ESTO item SUB3.

---

INTER/SUB3/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0011. MINUTES AT 142028 CRSE=+0001.

---

DD: Use SUB3 to find latest intercept course.

---

RANGE/WHITE+OWN/SUB3  
RANGE = +0004.500000 BEARING = +0000. AT TIME = 140936

---

DD: Find present range and bearing.

---

SETSP/WHITE+OWN/=30/=1  
THE SAILING PLAN HAS BEEN STARTED TIME= 141051

---

DD: Modify intercept course, maintain present speed.

---

ESTOP/ACT4/SUB4  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 141000 AND 141200  
OPPONENT GOING +0006. KNOTS ON COURSE +0003.

---

DD: Obtain another estimate of SS.

---

INTER/SUB4/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0008. MINUTES AT 142106 CRSE=+0001.

---

DD: Calculate latest intercept course.

---

INTER/SUB4/=45  
\* IF YOU TRAVEL AT +0045. KNOTS,  
INTERCEPTION IN +0005. MINUTES AT 141753 CRSE=+0001.

---

DD: Is SS within weapon range (2 1/4 miles or 3 minutes)?

---

---

RANGE/WHITE+OWN/SUB4  
RANGE = +0003.170000 BEARING = +0000. AT TIME = 141257

---

DD: Find present range and bearing of SS based on ESTO  
item SUB4.

---

ESTOP/ACT5/SUB5  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 141300 AND 141500  
OPPONENT GOING +0001. KNOTS ON COURSE -0013.

---

DD: Using SONAR item ACT5, create ESTO item SUB5.

---

INTER/SUB5/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0004. MINUTES AT 141947 CRSE=-0004.

---

DD: Find latest intercept course.

---

INTER/SUB5/=45  
IF YOU TRAVEL AT +0045. KNOTS,  
INTERCEPTION IN +0003. MINUTES AT 141821 CRSE=-0004.

---

DD: Is SS within weapon range? Torpedos travel at 45 Knots.

---

RANGE/WHITE+OWN/SUB5  
RANGE = +0002.000000 BEARING = -0004. AT TIME = 141539

---

DD: Find estimated range and bearing of SS using item SUB5.

---

SETSP/WHITE+OWN/=30/=-4  
THE SAILING PLAN HAS BEEN STARTED TIME= 141655

---

DD: Turn left 5° as ESTO item. SUB5 indicates a corresponding  
change has been made by SS.

---

ESTOP/ACT6/SUB6  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 141600 AND 141700  
OPPONENT GOING +0015. KNOTS ON COURSE -0119.

---

DD: Obtain new estimate of SS speed and course using latest sonar readings as stored in ACT6.

---

INTER/SUB6/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0004. MINUTES AT 142158 CRSE=-0093.

---

DD: Find new intercept course.

---

INTER/SUB6/=45  
IF YOU TRAVEL AT +0045. KNOTS,  
INTERCEPTION IN +0002. MINUTES AT 142029 CRSE=-0090.

---

DD: Is SS within weapon range?  
DD commander decides to fire a torpedo at  $-90^{\circ}$ .  
Results are given with referee functions at the end.

---

Commands and Queries Made by the Submarine Captain

---

USES<sub>N</sub>/RED+SON1+STEP/=1/=5  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Take five sonar readings starting now and continuing at one minute intervals.

---

USES<sub>N</sub>/RED+SON2/=1404/=1405/=1406/=1407/=1408  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Take sonar readings at indicated times. Store results in SON2.

---

USES<sub>N</sub>/RED+SON3/=1407/=1408/=1409/=1410/=1411  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Store readings for indicated times in SON3.

---

USES<sub>N</sub>/RED+SON4/=1410/=1411/=1412/=1413/=1414  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Store readings for times 14:10-14:14 in SON4.

---

USES<sub>N</sub>/RED+SON5/=1413/=1414/=1415/=1416/=1417  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Take indicated sonar readings.

---

USES<sub>N</sub>/RED+SON6/=1416/=1417/=1418/=1419/=1420  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Take indicated sonar readings.

---

USES<sub>N</sub>/RED+SON7/=1419/=1420/=1421/=1422/=1423  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Take indicated sonar readings.

---

---

ESTOP/RED+SON1/DD1  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 140001 AND 140201  
OPPONENT GOING +0015. KNOTS ON COURSE -0030.

---

SS: Obtain estimate of DD speed and course based on sonar readings stored in item SON1.

---

RANGE/RED+OWN/DD1/=1401/=2/=5  
RANGE = +0007.020000 BEARING = -0178. AT TIME = 140100  
RANGE = +0006.770000 BEARING = -0176. AT TIME = 140300  
RANGE = +0006.520000 BEARING = -0174. AT TIME = 140500  
RANGE = +0006.290000 BEARING = -0171. AT TIME = 140700  
RANGE = +0006.070000 BEARING = -0168. AT TIME = 140900

---

SS: Use ESTO item DD1 to obtain range and bearing of DD at two minute intervals.

---

OPINT/RED+DD1/=30  
IF RIVAL TRAVELS AT +0030. KNOTS,  
INTERCEPTION IN +0016. MINUTES AT 141956 CRSE=+0004.

---

SS: Using ESTO item DD1, can DD intercept me if he attempts an interception at 30 Knots?

---

SETSP/RED+OWN/=5/=4/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 140512

---

SS: Allow DD to get close. Maintain approximate course of DD.

---

ESTOP/RED+SON2/DD2  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 140400 AND 140500  
OPPONENT GOING +0018. KNOTS ON COURSE +0025.

---

SS: Obtain new estimate of DD to see if DD has started to intercept.

---

ESTOP/RED+SON2/DD2  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0004. READINGS BETWEEN 140400 AND 140700  
OPPONENT GOING +0025. KNOTS ON COURSE +0006.

---

SS: Make another estimate using SONAR item SON2 now that more readings have been made.

---

OPINT/RED+DD2/=30  
IF RIVAL TRAVELS AT +0030. KNOTS,  
INTERCEPTION IN +0013. MINUTES AT 142040 CRSE=+0001.

---

SS: Can DD intercept me?

---

RANGE/RED+OWN/DD2/=1405/=2/=5  
RANGE = +0006.250000 BEARING = -0178. AT TIME = 140500  
RANGE = +0005.590000 BEARING = -0179. AT TIME = 140700  
RANGE = +0004.920000 BEARING = +0179. AT TIME = 140900  
RANGE = +0004.260000 BEARING = +0178. AT TIME = 141100  
RANGE = +0003.600000 BEARING = +0177. AT TIME = 141300

---

SS: Use DD2 to find estimated range and bearing at two minute intervals, so that I can determine when DD will get within weapon range.

---

ESTOP/RED+SON3/DD3  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 140700 AND 140900  
OPPONENT GOING +0030. KNOTS ON COURSE +0002.

---

SS: Using SONAR item SON3, create ESTO item DD3.

---

SETSP/RED+OWN/=8/=2/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 141103

---

SS: Turn left 2°. Based on ESTO item DD3, DD is on a course of 2°.

---

SETSP/RED+OWN/=15/=6/=100/=1/=15/=-110/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 141202

---

SS: Start a maneuver to evade the DD.

---

ESTOP/RED+SON4/DD4  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0004. READINGS BETWEEN 141000 AND 141300  
OPPONENT GOING +0030. KNOTS ON COURSE +0001.

---

SS: Obtain new estimate of DD speed and course.

RANGE/RED+OWN/DD3/=1410/=2/=8

RANGE = +0004.340000 BEARING = -0179. AT TIME = 141000  
RANGE = +0003.550000 BEARING = -0179. AT TIME = 141200  
RANGE = +0002.900000 BEARING = +0177. AT TIME = 141400  
RANGE = +0001.840000 BEARING = +0159. AT TIME = 141600  
RANGE = +0001.280000 BEARING = +0115. AT TIME = 141800  
RANGE = +0001.770000 BEARING = +0069. AT TIME = 142000  
RANGE = +0002.810000 BEARING = +0050. AT TIME = 142200  
RANGE = +0003.980000 BEARING = +0042. AT TIME = 142400

SS: Find estimated range and bearing at two minute intervals.

ESTOP/RED+SON5/DD5

INCOMPLETE SENSOR READINGS TAKEN

BASED ON +0004. READINGS BETWEEN 141300 AND 141600  
OPPONENT GOING +0030. KNOTS ON COURSE +0001.

SS: Obtain new estimate; DD is still maintaining his old intercept course.

SETSP/RED+OWN/=15/=-130/=100

THE SAILING PLAN HAS BEEN STARTED TIME= 141628

SS: Add another course change to the maneuver.

RANGE/RED+OWN/DD4/=1412/=2/=6

RANGE = +0003.550000 BEARING = -0179. AT TIME = 141200  
RANGE = +0002.900000 BEARING = +0177. AT TIME = 141400  
RANGE = +0001.830000 BEARING = +0160. AT TIME = 141600  
RANGE = +0001.140000 BEARING = +0113. AT TIME = 141800  
RANGE = +0001.690000 BEARING = +0058. AT TIME = 142000  
RANGE = +0002.870000 BEARING = +0040. AT TIME = 142200

SS: Find estimated range and bearing.

SETSP/RED+OWN/=15/=-100/=100/=2/=15/=120/=100

THE SAILING PLAN HAS BEEN STARTED TIME= 141836

SS: Add two more course changes to the maneuver.

ESTOP/RED+SON6/DD6

INCOMPLETE SENSOR READINGS TAKEN

BASED ON +0004. READINGS BETWEEN 141600 AND 141900  
OPPONENT GOING +0030. KNOTS ON COURSE -0003.

SS: Latest estimate shows that DD is reacting to the maneuver.



---

ESTOP/RED+SON7/DD7  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 141900 AND 142000  
OPPONENT GOING +0030. KNOTS ON COURSE -0004.

---

SS: Obtain new estimate of DD speed and course; DD is starting  
to react to the maneuver.

---

RANGE/RED+OWN/DD6/=1416/=2/=5

RANGE = +0001.830000	BEARING = +0160.	AT TIME = 141600
RANGE = +0001.080000	BEARING = +0114.	AT TIME = 141800
RANGE = +0001.570000	BEARING = +0062.	AT TIME = 142000
RANGE = +0002.450000	BEARING = +0036.	AT TIME = 142200
RANGE = +0003.370000	BEARING = +0016.	AT TIME = 142400

---

SS: Find estimated range and bearing of DD. DD is within weapon  
range.

Functions Used by the Referee

RANGE/RED+OWN/SUB6/=1418/=1/=5  
 RANGE = +0000.050000 BEARING = -0029. AT TIME = 141800  
 RANGE = +0000.060000 BEARING = -0032. AT TIME = 141900  
 RANGE = +0000.030000 BEARING = +0179. AT TIME = 142000 ←  
 RANGE = +0000.060000 BEARING = +0172. AT TIME = 142100  
 RANGE = +0000.340000 BEARING = -0090. AT TIME = 142200

Referee: Requests distance between SS and estimate of SS as stored in item SUB6. SUB6 was used by DD to determine course of torpedo. Torpedo is fired at 14:18:29 and should explode two minutes later.

POS/SUB6/=1418/=1419/=1420/=1421

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
0080+	141800	+0040.14	-0030.02	014.7	-0119.04	+0000.
0080+	141900	+0040.13	-0030.03	014.7	-0119.04	+0000.
0080+	142000	+0040.13	-0030.03	014.7	-0119.04	+0000.
0080+	142100	+0040.13	-0030.04	014.7	-0119.04	+0000.

Referee: Find estimated position of SS for the times after the torpedo is fired.

RANGE/WHITE+OWN/RED+OWN/=1400/=1/=59

RANGE = +0007.150000 BEARING = +0000. AT TIME = 140000
RANGE = +0007.020000 BEARING = +0001. AT TIME = 140100
RANGE = +0006.890000 BEARING = +0002. AT TIME = 140200
RANGE = +0006.740000 BEARING = +0002. AT TIME = 140300
RANGE = +0006.590000 BEARING = +0002. AT TIME = 140400
RANGE = +0006.400000 BEARING = +0001. AT TIME = 140500
RANGE = +0006.000000 BEARING = +0000. AT TIME = 140600
RANGE = +0005.590000 BEARING = +0000. AT TIME = 140700
RANGE = +0005.170000 BEARING = +0000. AT TIME = 140800
RANGE = +0004.750000 BEARING = +0000. AT TIME = 140900
RANGE = +0004.340000 BEARING = +0000. AT TIME = 141000
RANGE = +0003.920000 BEARING = +0000. AT TIME = 141100
RANGE = +0003.550000 BEARING = +0000. AT TIME = 141200
RANGE = +0003.290000 BEARING = +0000. AT TIME = 141300
RANGE = +0002.900000 BEARING = -0002. AT TIME = 141400
RANGE = +0002.340000 BEARING = -0008. AT TIME = 141500
RANGE = +0001.830000 BEARING = -0019. AT TIME = 141600
RANGE = +0001.380000 BEARING = -0036. AT TIME = 141700
RANGE = +0001.080000 BEARING = -0065. AT TIME = 141800
RANGE = +0001.170000 BEARING = -0098. AT TIME = 141900
RANGE = +0001.550000 BEARING = -0117. AT TIME = 142000
RANGE = +0002.030000 BEARING = -0129. AT TIME = 142100

Referee: Find true range and bearing from DD to SS starting at 14:00 and continuing at one minute intervals until the end of the game.

POS/WHITE+OWN/=1356/=1358/=1400/=1401/=1402/  
 =1403/=1404/=1405/=1406/=1407/=1408/=1409/=1410/=1411/  
 =1412/=1413/=1414/=1415/=1416/=1417/=1418

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
THE TIME	135600	OCCURS	BEFORE THE	GAME	BEGAN	
THE TIME	135800	OCCURS	BEFORE THE	GAME	BEGAN	
WHITE	140000	+0040.00	-0030.00	015.0	-0030.00	+0000.
WHITE	140100	+0040.00	-0030.00	015.0	-0030.00	+0000.
WHITE	140200	+0040.01	-0030.01	015.0	TURN	+0000.
WHITE	140300	+0040.01	-0030.01	015.0	TURN	+0000.
WHITE	140400	+0040.02	-0030.01	015.0	+0030.00	+0000.
WHITE	140500	+0040.02	-0030.00	022.5	TURN	+0000.
WHITE	140600	+0040.03	-0030.00	030.0	+0002.00	+0000.
WHITE	140700	+0040.04	-0030.00	030.0	+0002.00	+0000.
WHITE	140800	+0040.05	-0030.00	030.0	+0002.00	+0000.
WHITE	140900	+0040.05	-0030.00	030.0	+0002.00	+0000.
WHITE	141000	+0040.06	-0030.00	030.0	+0002.00	+0000.
WHITE	141100	+0040.07	-0030.00	030.0	+0001.00	+0000.
WHITE	141200	+0040.08	-0030.00	030.0	+0001.00	+0000.
WHITE	141300	+0040.09	-0030.00	030.0	+0001.00	+0000.
WHITE	141400	+0040.10	-0030.00	030.0	+0001.00	+0000.
WHITE	141500	+0040.10	-0030.00	030.0	+0001.00	+0000.
WHITE	141600	+0040.11	-0030.00	030.0	+0001.00	+0000.
WHITE	141700	+0040.12	-0030.00	030.0	-0004.00	+0000.
WHITE	141800	+0040.13	-0030.00	030.0	-0004.00	+0000.

POS/WHITE+OWN/=1419/=1420/  
 =1421/=1422/=1423/=1424/=1425/=1426/=1427/=1428/=1429/  
 =1430/=1431/=1432/=1434/=1436/=1438/=1439/=1440/=1442

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
WHITE	141900	+0040.14	-0030.00	030.0	-0004.00	+0000.
WHITE	142000	+0040.15	-0030.00	030.0	-0004.00	+0000.
WHITE	142100	+0040.15	-0030.00	030.0	-0004.00	+0000.
WHITE	142200	+0040.16	-0030.00	030.0	-0004.00	+0000.
WHITE	142300	+0040.17	-0030.00	030.0	TURN	+0000.
WHITE	142400	+0040.18	-0030.01	030.0	TURN	+0000.
WHITE	142500	+0040.17	-0030.02	030.0	TURN	+0000.
WHITE	142600	+0040.17	-0030.03	030.0	-0148.00	+0000.
WHITE	142700	+0040.16	-0030.04	030.0	-0148.00	+0000.
WHITE	142800	+0040.16	-0030.04	030.0	-0148.00	+0000.
WHITE	142900	+0040.15	-0030.05	030.0	TURN	+0000.
WHITE	143000	+0040.14	-0030.04	030.0	+0141.00	+0000.
WHITE	143100	+0040.13	-0030.03	030.0	+0141.00	+0000.
WHITE	143200	+0040.13	-0030.03	030.0	+0141.00	+0000.
WHITE	143400	+0040.12	-0030.01	030.0	+0141.00	+0000.
WHITE	143600	+0040.10	-0030.00	030.0	+0159.00	+0000.
WHITE	143800	+0040.09	-0029.99	030.0	+0170.00	+0000.
WHITE	143900	+0040.08	-0029.99	030.0	+0170.00	+0000.
WHITE	144000	+0040.07	-0029.99	030.0	+0170.00	+0000.
WHITE	144200	+0040.05	-0029.99	030.0	+0170.00	+0000.

Referee: Find position of DD for the entire game. A course of "TURN" indicates that the DD is turning.

POS/RED+OWN/=1356/=1358/=1400/=1401/=1402/  
 =1403/=1404/=1405/=1406/=1407/=1408/=1409/=1410/=1411/  
 =1412/=1413/=1414/=1415/=1416/=1417/=1418

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
	THE TIME	135600	OCCURS	BEFORE	THE GAME	BEGAN
	THE TIME	135800	OCCURS	BEFORE	THE GAME	BEGAN
OORED	140000	+0040.12	-0030.00	005.0	+0000.00	+0100.
OORED	140100	+0040.12	-0030.00	005.0	+0000.00	+0100.
OORED	140200	+0040.12	-0030.00	005.0	+0000.00	+0100.
OORED	140300	+0040.12	-0030.00	005.0	+0000.00	+0100.
OORED	140400	+0040.13	-0030.00	005.0	+0000.00	+0100.
OORED	140500	+0040.13	-0030.00	005.0	+0000.00	+0100.
OORED	140600	+0040.13	-0030.00	005.0	+0004.00	+0100.
OORED	140700	+0040.13	-0030.00	005.0	+0004.00	+0100.
OORED	140800	+0040.13	-0030.00	005.0	+0004.00	+0100.
OORED	140900	+0040.13	-0030.00	005.0	+0004.00	+0100.
OORED	141000	+0040.13	-0030.00	005.0	+0004.00	+0100.
OORED	141100	+0040.14	-0030.00	005.0	+0004.00	+0100.
OORED	141200	+0040.14	-0030.00	008.0	+0002.00	+0100.
OORED	141300	+0040.14	-0030.00	015.0	+0006.00	+0100.
OORED	141400	+0040.14	-0030.00	015.0	-0110.00	+0100.
OORED	141500	+0040.14	-0030.01	015.0	-0110.00	+0100.
OORED	141600	+0040.14	-0030.01	015.0	-0110.00	+0100.
OORED	141700	+0040.14	-0030.02	015.0	-0130.00	+0100.
OORED	141800	+0040.14	-0030.02	015.0	-0130.00	+0100.

POS/RED+OWN/=1419/=1420/  
 =1421/=1422/=1423/=1424/=1425/=1426/=1427/=1428/=1429/  
 =1430/=1431/=1432/=1434/=1436/=1438/=1439/=1440/=1442

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
OORED	141900	+0040.13	-0030.03	015.0	-0100.00	+0100.
OORED	142000	+0040.13	-0030.03	015.0	-0100.00	+0100.
OORED	142100	+0040.13	-0030.04	015.0	TURN	+0100.

Referee: Find position, speed, course and depth of SS for the entire game.

### 3.2 Game Two

In this game, each side attempts to attack its adversary. The initial patrol sailing plans are shown in Fig. 3.2.

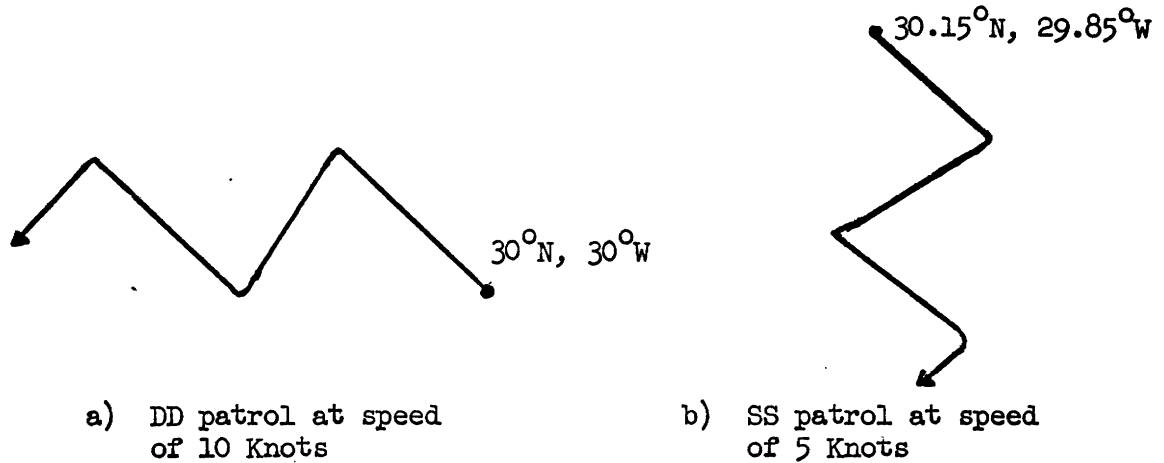


Figure 3.2 Initial Patrol Plans of Each Player

Figure 3.3 shows the entire game. At first both sides attempt to intercept. The submarine, after going on an intercept course for about ten minutes, starts a maneuver at 10:14 in an attempt to mislead the destroyer and then to return to an intercept course. This tactic works well at first and the destroyer changes course. However, immediately afterwards, the destroyer captain receives new information and learns that the submarine's range is only 0.28 miles. He therefore launches a weapon and wins the game. The final part of the game, including the submarine's maneuver, is shown in Fig. 3.4. This figure shows that the destroyer's estimate of the submarine as given in ESTO item SUB6 is very close to the actual position of the submarine.

An annotated listing of all functions used in the game follows.

<u>Functions</u>	<u>Page Number</u>
Initial Positions and Sailing Plans of Both Players	42
Commands and Queries Made By the Destroyer Captain	43
Commands and Queries Made By the Submarine Captain	48
Functions Used by the Referee	53

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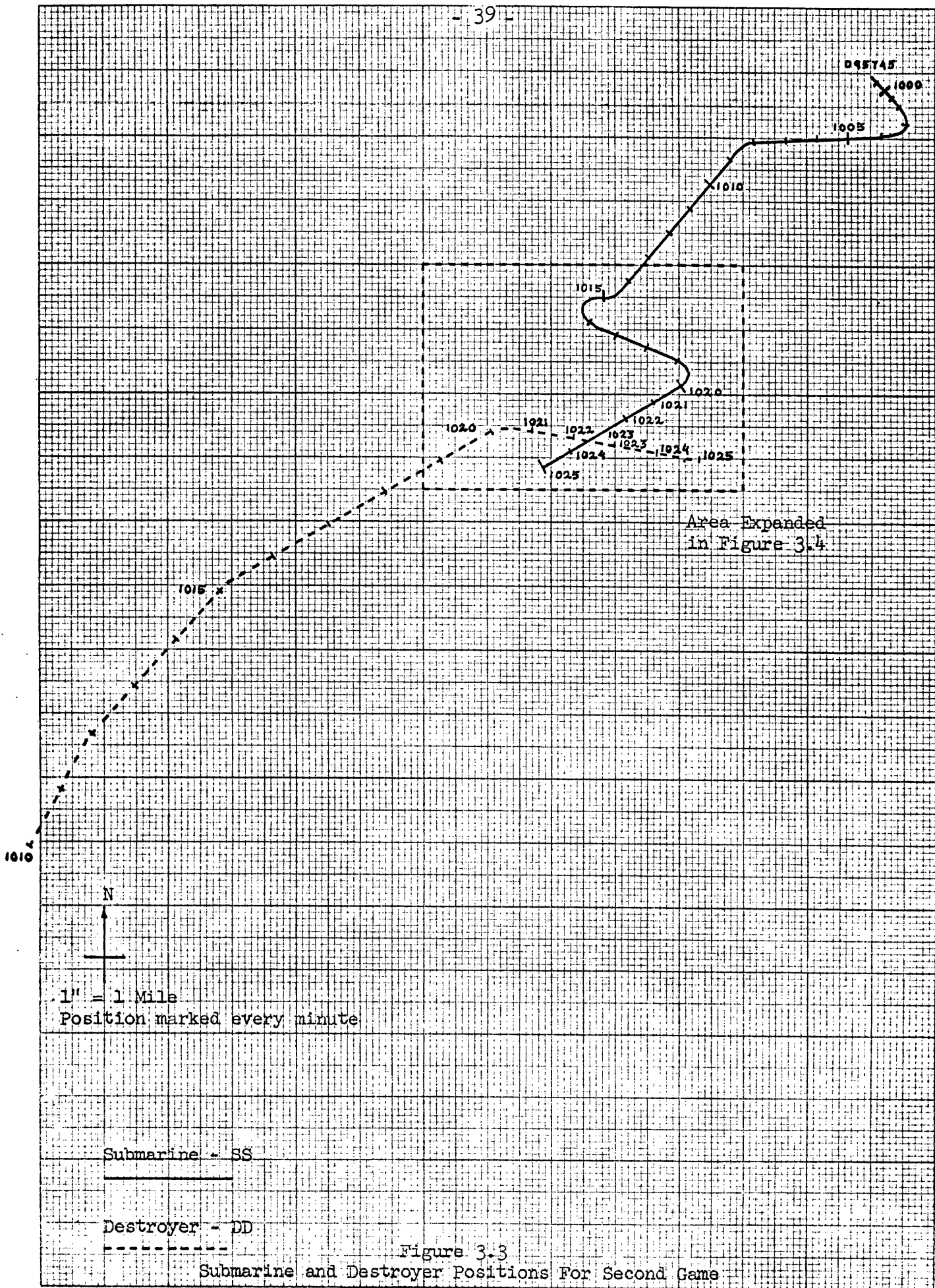


Figure 3.3  
Submarine and Destroyer Positions For Second Game

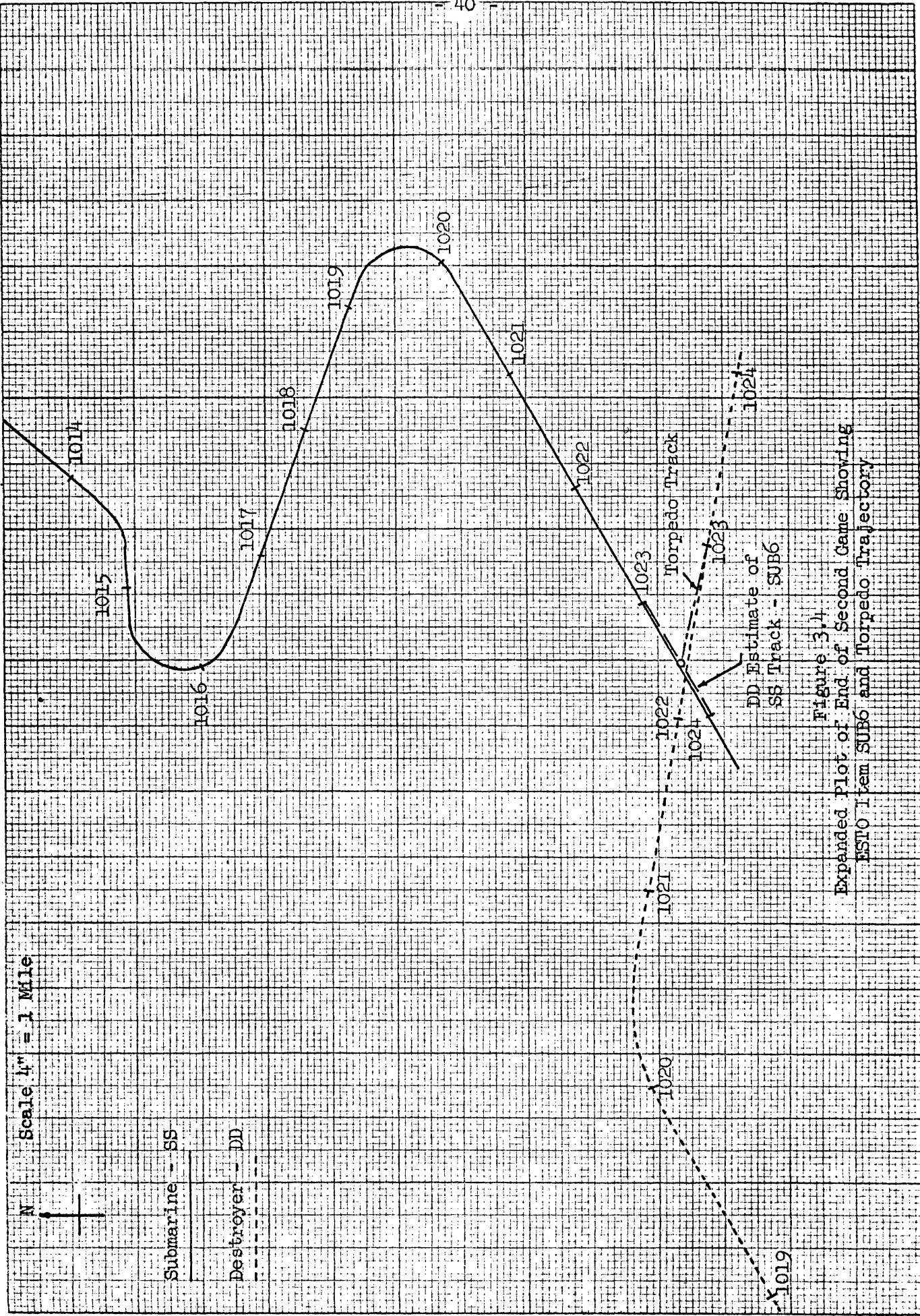


Figure 3.1.  
 Expanded Plot of End of Second Game Showing  
 SS101 Track and Torpedo Trajectory



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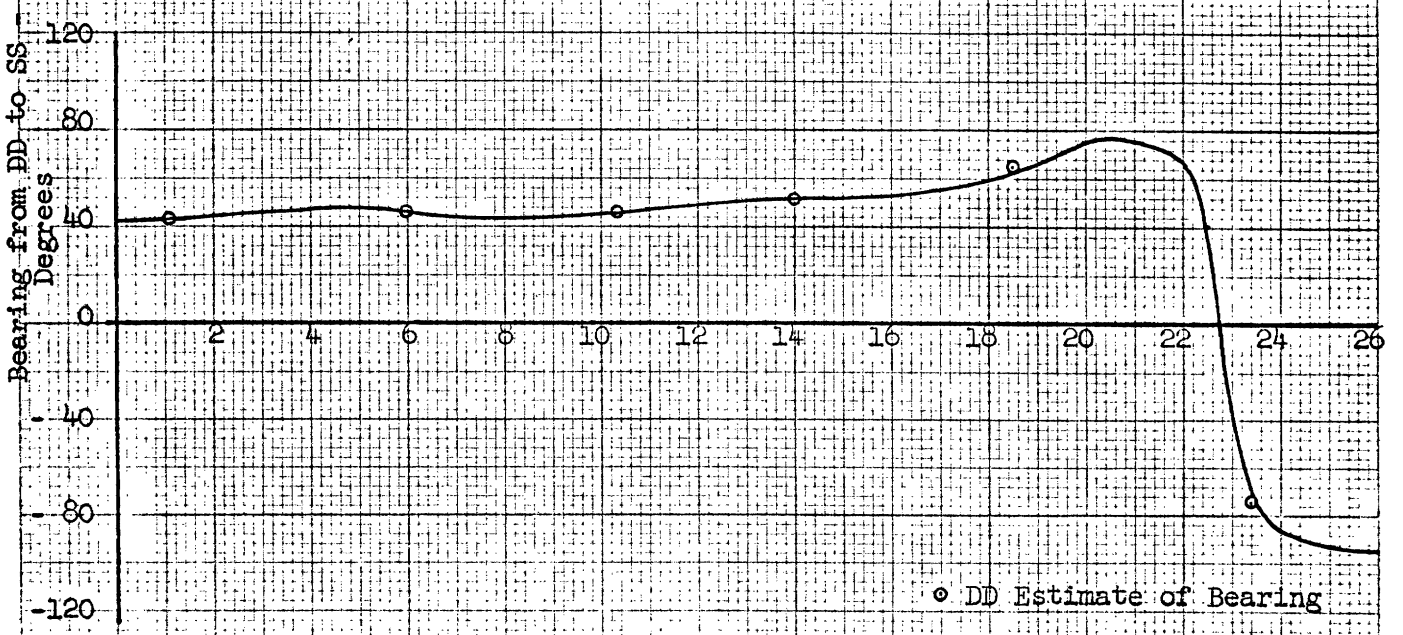
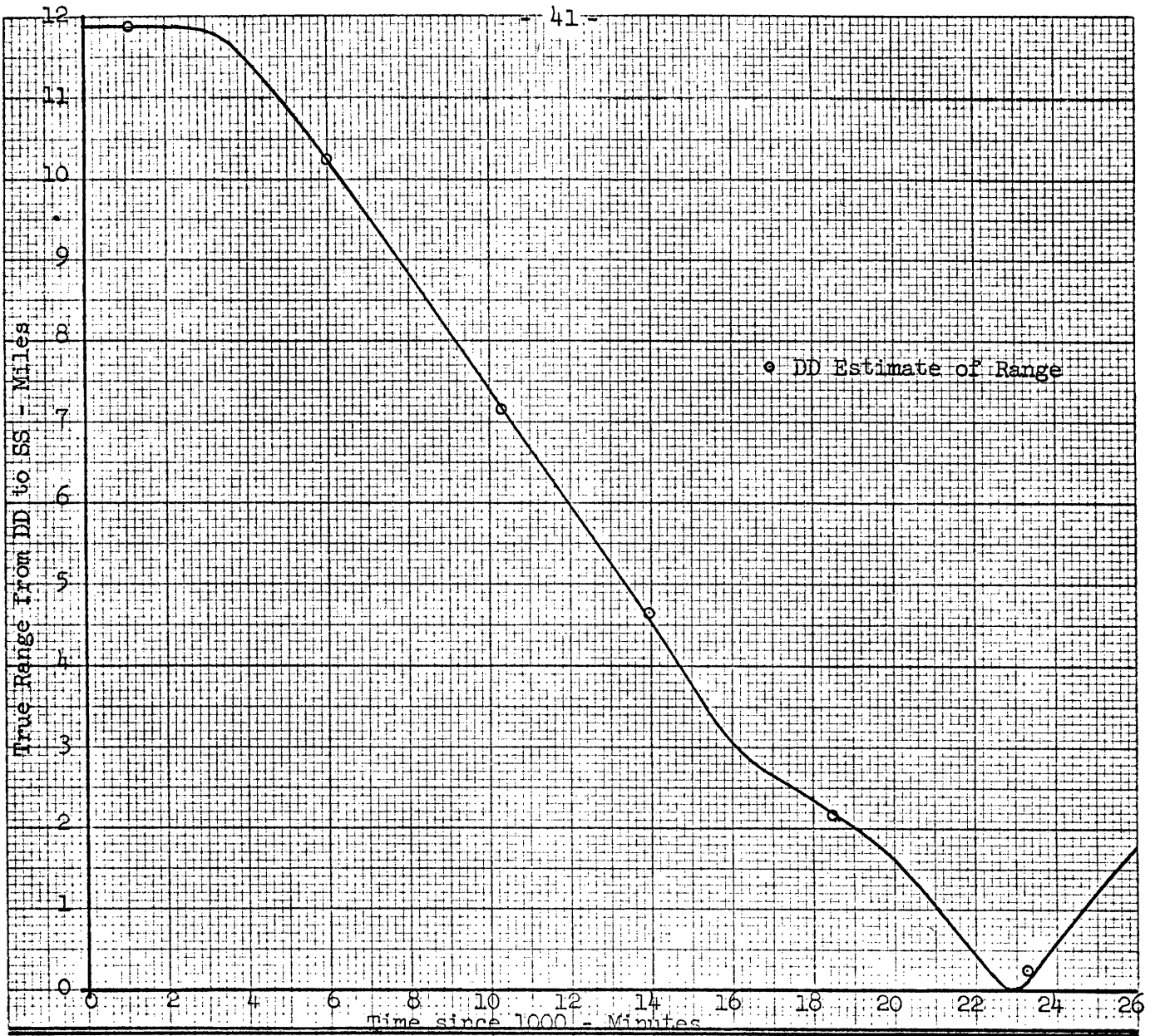


Figure 3.5  
Range and Bearing from Destroyer to Submarine for Second Game

Initial Positions and Sailing Plans of Both Players

INTLZ  
INTLZ WAS ENTERED

Initialize Game

START/RED+OWN/=30.15/=-29.85/WHITE+OWN/=30/=-30  
INITIAL POSITION HAS BEEN STORED FOR TIME = 095741

Set initial positions: Submarine (SS) 30.15°N 29.85°W  
Destroyer (DD) 30°N +30°W

SETSP/RED+OWN/=5/=135/=100/=30/=5/=-135/=100/=30/  
=5/=135/=100/=30/=5/=-135/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 095757

Set initial sailing plan for SS:

SPEED	COURSE	DEPTH	DURATION
5 Knots	135°	100'	30 Min.
5	-135	100	30
5	135	100	30
5	-135	100	Not Specified

SETSP/WHITE+OWN/=10/=-45/=30/=10/=-135/=30/=10/=-45/=30/  
=10/=-135  
THE SAILING PLAN HAS BEEN STARTED TIME= 095804

Set initial sailing plan for DD:

SPEED	COURSE	DURATION
10	-45°	30
10	-135°	30
10	-45°	30
10	-135°	Not Specified

Commands and Queries Made by the Destroyer Captain

USES/WHITE+ACT1+STEP/=1/=4  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Requests 4 sonar readings be taken starting immediately with 1 minute intervals.

USES/WHITE+ACT2/=1004/=1005/=1006/=1007  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Requests that sonar readings be taken at 1004, 1005, 1006, 1007 and that this SONAR item be labeled ACT2.

USES/WHITE+ACT3/=1008/=1009/=1010/=1011  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Requests that more advance sonar readings be taken.

USES/WHITE+ACT4/=1012/=1013/=1014/=1015  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Requests another set of sonar readings be taken.

USES/WHITE+ACT5/=1016/=1017/=1018/=1019  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Requests a fifth set of sonar readings be taken.

USES/WHITE+ACT6/=1020/=1021/=1022/=1023  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Requests last of advance SONAR items be taken starting at 10.20. (Note that ACT2 through ACT6 cover times from 1004 to 1023 in 1 minute intervals.)

ESTOP/ACT1/SUB1  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 095810 AND 100010  
OPPONENT GOING +0005. KNOTS ON COURSE +0135.

DD: Requests estimate of SS course and speed (sailing plan) based on SONAR item ACT1 and creates ESTO item SUB1 containing the estimated sailing plan.  
(Note: SS true course and speed are as given.)

RANGE/WHITE+OWN/SUB1  
RANGE = +0011.870000 BEARING = +0045. AT TIME = 100111

DD: Requests an estimate of present range and bearing from DD to SS based on ESTO item SUB1.  
(Note: Since SS is on course and speed of ESTO item SUB1, then this range is quite accurate.)

INTER/SUB1/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0024. MINUTES AT 102529 CRSE=+0055.

DD: Requests an interception course which will allow interception with SS if SS continues on the sailing plan currently estimated (SUB1) and DD travels at 30 Knots.

SETSP/WHITE+OWN/=30/=55  
THE SAILING PLAN HAS BEEN STARTED TIME= 100232

DD: Changes sailing plan to follow interception course given above.

ESTOP/ACT2/SUB2  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 100400 AND 100500  
OPPONENT GOING +0015. KNOTS ON COURSE -0093.

DD: Requests a sailing plan based on second set of sonar readings.  
(Note: Course and speed of SS are as given.)

RANGE/WHITE+OWN/SUB2  
RANGE = +0010.260000 BEARING = +0047. AT TIME = 100557

DD: Requests current range and bearing based on ESTO item SUB2.

INTER/SUB2/=20  
IF YOU TRAVEL AT +0020. KNOTS,  
INTERCEPTION IN +0021. MINUTES AT 102713 CRSE=+0019.

DD: Requests an interception course for a DD speed of 20 Knots.

INTER/SUB2/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0015. MINUTES AT 102131 CRSE=+0029.

DD: Requests an interception course for a DD speed of 30 Knots.

SETSP/WHITE+OWN/=30/=28  
THE SAILING PLAN HAS BEEN STARTED TIME= 100747

DD: Modifies sailing plan based principally on previous interception calculations.

ESTOP/ACT3/SUB3  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 100800 AND 100900  
OPPONENT GOING +0014. KNOTS ON COURSE -0125.

DD: Requests an estimated sailing plan for the third SONAR item ACT3.  
(Note: DD caught SS in a turn from  $-93^{\circ}$  to  $-141^{\circ}$ .)

INTER/SUB3/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0010. MINUTES AT 102016 CRSE=+0042.

DD: Requests a new interception course for a 30 Knot speed of DD.

RANGE/WHITE+OWN/SUB3  
RANGE = +0007.190000 BEARING = +0046. AT TIME = 101021

DD: Requests an estimate of current range.  
(Note: Because SS was turning when DD took sonar readings this range estimate is somewhat different from the true range.)

SETSP/WHITE+OWN/=30/=42  
THE SAILING PLAN HAS BEEN STARTED TIME= 101147

DD: Modifies sailing plan to accomplish interception as calculated above.  
(Note: Estimate based on a course which is  $16^{\circ}$  in error because of SS turn.)

INTER/SUB5/=10  
NO POSSIBLE INTERCEPTION AT THIS SPEED.

DD: Requests an interception course for 10 Knots. Due to the present positions of the ships and SS sailing plan DD cannot intercept at this speed.

RANGE/WHITE+OWN/SUB5  
RANGE = +0002.160000 BEARING = +0065. AT TIME = 101828

DD: Requests current range to SS.

SETSP/WHITE+OWN/=20/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 101950

DD: Changes course according to intercept at 20 Knots previously calculated.  
(Note: SS change to  $-120^{\circ}$  took place at 101915.)

INTER/SUB5/=45  
IF YOU TRAVEL AT +0045. KNOTS,  
INTERCEPTION IN +0002. MINUTES AT 102455 CRSE=+0094.

DD: Asks for torpedo intercept based on SUB5.  
(Note: A torpedo fired on this course would miss badly.)

ESTOP/ACT6/SUB6  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 102000 AND 102200  
OPPONENT GOING +0015. KNOTS ON COURSE -0121.

DD: Requests new estimate of course and speed of SS based on later readings.  
(Note: True SS course is  $-120^{\circ}$ . DD has an accurate estimate of SS sailing plan, but SS got an estimate of DD slightly earlier which is more accurate. However, DD asked for a torpedo intercept at the same time. See next statement.)

INTER/SUB6/=45  
IF YOU TRAVEL AT +0045. KNOTS,  
INTERCEPTION IN +0000. MINUTES AT 102331 CRSE=-0077.

DD: Requests torpedo intercept course. (This statement was piggy-backed with the creation of ESTO item SUB6 thus enabling DD to sink SS.) (The execution of the earlier intercept on SUB5 also was in the same set as was the range below.)

RANGE/WHITE+OWN/SUB6  
RANGE = +0000.280000 BEARING = -0074. AT TIME = 102320

DD: Requests current estimated range.

ESTOP/ACT4/SUB4  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 101200 AND 101300  
OPPONENT GOING +0015. KNOTS ON COURSE -0141.

DD: Requests new estimate of SS sailing plan using fourth SONAR  
item requested.  
(Note: SS course and speed are correct as given.)

RANGE/WHITE+OWN/SUB4  
RANGE = +0004.670000 BEARING = +0052. AT TIME = 101347

DD: Requests current estimate of range and bearing to SS.

INTER/SUB4/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0006. MINUTES AT 102011 CRSE=+0060.

DD: Requests interception course based on latest estimate  
of SS sailing plan.

SETSP/WHITE+OWN/=30/=60  
THE SAILING PLAN HAS BEEN STARTED TIME= 101507

DD: Changes course based on last interception calculated.  
(Note: SS changed course about 50 sec. before this change.)

ESTOP/ACT5/SUB5  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 101600 AND 101700  
OPPONENT GOING +0014. KNOTS ON COURSE +0119.

DD: Requests estimate be made using fifth set of sonar readings.  
(Note: DD caught SS in a turn from  $-95^{\circ}$  to  $110^{\circ}$ . This is  
part of the maneuver designed to confuse DD.)

INTER/SUB5/=30  
IF YOU TRAVEL AT +0030. KNOTS,  
INTERCEPTION IN +0007. MINUTES AT 102513 CRSE=+0086.

DD: Requests interception course.  
(Note: SS has already programmed a change to  $-120^{\circ}$  to take  
effect at 101915. This will considerably shorten interception  
time.)

INTER/SUB5/=20  
IF YOU TRAVEL AT +0020. KNOTS,  
INTERCEPTION IN +0017. MINUTES AT 103530 CRSE=+0100.

DD: Requests an interception course for 20 Knots.

Commands and Queries Made By the Submarine Captain

USES<sub>N</sub>/RED+SON<sub>1</sub>+STEP/=1/=4  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Requests that 4 sonar readings be taken starting immediately in 1 minute intervals.

USES<sub>N</sub>/RED+SON<sub>2</sub>/=1004/=1005/=1006/=1007  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Requests that sonar readings be taken at 1004, 1005, 1006 and 1007 and that this SONAR item be labeled SON2.

USES<sub>N</sub>/RED+SON<sub>3</sub>/=1008/=1009/=1010/=1011  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Requests in advance that sonar readings be taken.

USES<sub>N</sub>/RED+SON<sub>4</sub>/=1012/=1013/=1014/=1015  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Requests that another set of sonar readings be taken.

USES<sub>N</sub>/RED+SON<sub>5</sub>/=1016/=1017/=1018/=1019  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

DD: Requests a fifth set of sonar readings well in advance.

USES<sub>N</sub>/RED+SON<sub>6</sub>/=1020/=1021/=1022/=1023  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Requests a last set of advance sonar readings be taken starting at 1020. (Note that SON2 through SON6 cover the time interval 1004 to 1023 in 1 minute intervals.)



ESTOP/RED+SON1/DD1  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 095823 AND 095923  
OPPONENT GOING +0010. KNOTS ON COURSE -0045.

SS: Requests estimate of DD sailing plan based on SONAR item  
SON1 and creates ESTO item DDL containing the estimated plan.  
(Note: DD true course and speed are as shown.)

RANGE/RED+OWN/DD1  
RANGE = +0011.870000 BEARING = -0134. AT TIME = 100131

DD: Requests an estimate of present range and bearing from SS to  
DD based on ESTO item DDL.  
(Note: Since DD is on course and speed given in ESTO item  
DDL, then this range is quite accurate.)

INTER/RED+DD1/=15  
IF YOU TRAVEL AT +0015. KNOTS,  
INTERCEPTION IN +0064. MINUTES AT 110606 CRSE=-0093.

SS: Requests a course which will allow interception with DD if DD  
continues on the sailing plan estimated in DDL and if SS travels  
at 15 Knots.

SETSP/RED+OWN/=15/=-93/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 100239

SS: Modifies sailing plan to accomplish interception with DD based  
on previous interception request.

ESTOP/RED+SON2/DD2  
INCOMPLETE SENSOR READINGS TAKEN  
TOO FEW READINGS TO USE ESTOP

SS: Requests an estimate using the second set of sonar readings  
before 2 readings have been taken.

RANGE/RED+OWN/DD1  
RANGE = +0011.680000 BEARING = -0131. AT TIME = 100418

DD: Requests another estimate of range based on ESTO item DDL.  
(Note: Since DD changed course at 100232 then this range is  
considerably in error. The new sailing plan of DD is now 30  
Knots at 55° while this estimate is based on 10 Knots at -45°.)

ESTOP/RED+SON2/DD2  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 100400 AND 100500  
OPPONENT GOING +0022. KNOTS ON COURSE +0044.

SS: Tries again to get an estimate using SONAR item DD2. This time 2 readings have been taken and an estimate can be made. (Note: These readings are taken while DD is coming out of its first course change. After turn is complete course is 55° and speed is 30 Knots.)

ESTOP/RED+SON2/DD2  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 100400 AND 100600  
OPPONENT GOING +0026. KNOTS ON COURSE +0050.

SS: Requests that a later estimate be made with the second set of sonar readings. The old DD2 is deleted and the newer and more accurate estimate is substituted.

RANGE/RED+OWN/DD2  
RANGE = +0009.760000 BEARING = -0133. AT TIME = 100646

SS: Requests an estimate of range and bearing.

INTER/RED+DD2/=15  
IF YOU TRAVEL AT +0015. KNOTS,  
INTERCEPTION IN +0014. MINUTES AT 102113 CRSE=-0141.

SS: Requests an interception course for SS speed of 15 Knots.

SETSP/RED+OWN/=15/=-141/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 100810

SS: Changes sailing plan based on estimated interception course.

ESTOP/RED+SON3/DD3  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 100800 AND 100900  
OPPONENT GOING +0030. KNOTS ON COURSE +0029.

SS: Requests an estimated sailing plan for DD based on the third SONAR item. (Note: True sailing plan is 30 Knots at 28 degrees.)

INTER/RED+DD3/=15  
IF YOU TRAVEL AT +0015. KNOTS,  
INTERCEPTION IN +0010. MINUTES AT 102115 CRSE=-0089.

SS: Requests an interception course for an SS speed of 15  
Knots based on DD3.

RANGE/RED+OWN/DD3/=1010/=2/=5

RANGE = +0007.430000	BEARING = -0133.	AT TIME = 101000
RANGE = +0005.990000	BEARING = -0130.	AT TIME = 101200
RANGE = +0004.590000	BEARING = -0124.	AT TIME = 101400
RANGE = +0003.270000	BEARING = -0114.	AT TIME = 101600
RANGE = +0002.180000	BEARING = -0092.	AT TIME = 101800

SS: Requests a set of range and bearing estimates be made  
assuming that SS remains on current sailing plan and  
DD remains on the estimated sailing plan DD3. The esti-  
mates start at 1010 and continue in 2 minute increments  
for a total of 5 readings.

SETSP/RED+OWN/=15/=-95/=100

THE SAILING PLAN HAS BEEN STARTED TIME= 101419

SS: Changes course based on last intercept calculated.

SETSP/RED+OWN/=15/=110/=100/=4/=15/=-120/=100

THE SAILING PLAN HAS BEEN STARTED TIME= 101515

SS: Continues the violent maneuver begun at 101419 by setting  
a new sailing plan. The total effect of both changes is given  
in the table below:

<u>Course</u>	<u>Speed</u>	<u>Depth</u>	<u>Duration</u>
-141	15	100	(Sailing plan before 101419)
-95	15	100	56 Sec. (started at 101419)
110	15	100	4 min.
-120	15	100	Not specified.

SS hopes the violence and variety of maneuver will mislead DD.

ESTOP/RED+SON4/DD4

ALL SENSOR READINGS TAKEN

BASED ON +0004. READINGS BETWEEN 101200 AND 101500

OPPONENT GOING +0030. KNOTS ON COURSE +0042.

SS: Gets latest estimate of DD sailing plan. (Note: DD  
changed sailing plan only 7 sec. after last sonar read-  
ing used for this estimate.)

INTER/RED+DD4/=15

IF YOU TRAVEL AT +0015. KNOTS,  
INTERCEPTION IN +0004. MINUTES AT 102145 CRSE=-0061.

SS: Requests interception course for last estimate of DD  
sailing plan.

ESTOP/RED+SON5/DD5

ALL SENSOR READINGS TAKEN

BASED ON +0004. READINGS BETWEEN 101600 AND 101900  
OPPONENT GOING +0030. KNOTS ON COURSE +0060.

SS: Gets latest estimate of DD sailing plan. (Note: Sailing plan is correct but again DD changed sailing plan almost immediately after last sonar reading was taken -- at 101950 DD went to a sailing plan of 20 Knots at 100°.)

RANGE/RED+OWN/DD5/=1020/=2/=5

RANGE = +0001.610000	BEARING = -0102.	AT TIME = 102000
RANGE = +0000.490000	BEARING = -0034.	AT TIME = 102200
RANGE = +0001.540000	BEARING = +0041.	AT TIME = 102400
RANGE = +0003.000000	BEARING = +0050.	AT TIME = 102600
RANGE = +0004.490000	BEARING = +0053.	AT TIME = 102800

SS: Requests range estimates based on DDS over an 8 minute range to enable SS to fire at the proper time. (Note: change in sailing plan of DD makes these readings invalid.)

USES/RED+SON11+STEP/=0.3/=5

SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Requests 5 sonar readings be taken at .3 minute intervals to establish exact position of DD.

ESTOP/RED+SON11/DD11

ALL SENSOR READINGS TAKEN

BASED ON +0005. READINGS BETWEEN 102052 AND 102204  
OPPONENT GOING +0020. KNOTS ON COURSE +0100.

SS: Obtains new sailing plan estimate. (Note: Is correct as given.)

INTER/RED+DD11/=45

IF YOU TRAVEL AT +0045. KNOTS,  
INTERCEPTION IN +0003. MINUTES AT 102745 CRSE=+0094.

SS: Requests a torpedo interception course. (This statement was typed and run after ESTOP which created DD1 was typed out. If this had been piggybacked with the ESTOP then SS would have gotten the DD since the ESTOP DD11 was executed before ESTOP SUB6. The SS lost about 2 minutes because of this.)

Functions Used by the Referee

RANGE/RED+OWN/SUB6/=1023/=1/=5

RANGE = +0000.010000 BEARING = +0119. AT TIME = 102300  
RANGE = +0000.010000 BEARING = +0127. AT TIME = 102400  
RANGE = +0000.020000 BEARING = +0130. AT TIME = 102500  
RANGE = +0000.020000 BEARING = +0132. AT TIME = 102600  
RANGE = +0000.030000 BEARING = +0133. AT TIME = 102700

Referee: Requests distance between the true position of SS and the estimate of SS position used by DD when second request for torpedo course was made. The DD estimate is quite good.

POS/SUB6/=1023/=1024/=1025/=1026

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
0080+	102300	+0030.10	-0029.89	014.9	-0121.22	+0000.
0080+	102400	+0030.10	-0029.89	014.9	-0121.22	+0000.
0080+	102500	+0030.10	-0029.90	014.9	-0121.22	+0000.
0080+	102600	+0030.10	-0029.90	014.9	-0121.22	+0000.

Referee: Requests position information of the estimated SS sailing plan which was made by DD. (True position is requested later.)

RANGE/WHITE+OWN/RED+OWN/=1000/=1/=59

RANGE = +0011.870000 BEARING = +0043. AT TIME = 100000  
RANGE = +0011.870000 BEARING = +0044. AT TIME = 100100  
RANGE = +0011.870000 BEARING = +0046. AT TIME = 100200  
RANGE = +0011.840000 BEARING = +0047. AT TIME = 100300  
RANGE = +0011.490000 BEARING = +0049. AT TIME = 100400  
RANGE = +0010.930000 BEARING = +0048. AT TIME = 100500  
RANGE = +0010.230000 BEARING = +0047. AT TIME = 100600  
RANGE = +0009.550000 BEARING = +0046. AT TIME = 100700  
RANGE = +0008.870000 BEARING = +0044. AT TIME = 100800  
RANGE = +0008.160000 BEARING = +0045. AT TIME = 100900  
RANGE = +0007.430000 BEARING = +0046. AT TIME = 101000  
RANGE = +0006.710000 BEARING = +0048. AT TIME = 101100  
RANGE = +0006.000000 BEARING = +0050. AT TIME = 101200  
RANGE = +0005.260000 BEARING = +0051. AT TIME = 101300  
RANGE = +0004.520000 BEARING = +0053. AT TIME = 101400  
RANGE = +0003.800000 BEARING = +0053. AT TIME = 101500  
RANGE = +0003.100000 BEARING = +0054. AT TIME = 101600  
RANGE = +0002.710000 BEARING = +0057. AT TIME = 101700  
RANGE = +0002.370000 BEARING = +0061. AT TIME = 101800  
RANGE = +0002.050000 BEARING = +0067. AT TIME = 101900  
RANGE = +0001.620000 BEARING = +0076. AT TIME = 102000  
RANGE = +0001.020000 BEARING = +0076. AT TIME = 102100  
RANGE = +0000.480000 BEARING = +0069. AT TIME = 102200  
RANGE = +0000.140000 BEARING = -0041. AT TIME = 102300  
RANGE = +0000.640000 BEARING = -0086. AT TIME = 102400  
RANGE = +0001.180000 BEARING = -0091. AT TIME = 102500  
RANGE = +0001.730000 BEARING = -0093. AT TIME = 102600  
RANGE = +0002.280000 BEARING = -0094. AT TIME = 102700  
RANGE = +0002.830000 BEARING = -0094. AT TIME = 102800  
RANGE = +0003.380000 BEARING = -0095. AT TIME = 102900

Referee: Requests true range and bearing from DD to SS for 1 minute intervals from the start of the game (1000) to a short time after the games end. (Points after 1030 edited out.)

POS/WHITE+OWN/=0956/=0958/=1000/=1001/=1002/  
 =1003/=1004/=1005/=1006/=1007/=1008/=1009/=1010/=1011/  
 =1012/=1013/=1014/=1015/=1016/=1017/=1018

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
THE TIME	095600	OCCURS BEFORE THE GAME BEGAN				
WHITE	095800	+0030.00	-0030.00	010.0	-0045.00	+0000.
WHITE	100000	+0030.00	-0030.01	010.0	-0045.00	+0000.
WHITE	100100	+0030.01	-0030.01	010.0	-0045.00	+0000.
WHITE	100200	+0030.01	-0030.01	010.0	-0045.00	+0000.
WHITE	100300	+0030.01	-0030.01	020.0	TURN	+0000.
WHITE	100400	+0030.02	-0030.01	020.0	TURN	+0000.
WHITE	100500	+0030.02	-0030.01	030.0	+0055.00	+0000.
WHITE	100600	+0030.03	-0030.00	030.0	+0055.00	+0000.
WHITE	100700	+0030.03	-0029.99	030.0	+0055.00	+0000.
WHITE	100800	+0030.04	-0029.98	030.0	TURN	+0000.
WHITE	100900	+0030.04	-0029.98	030.0	+0028.00	+0000.
WHITE	101000	+0030.05	-0029.98	030.0	+0028.00	+0000.
WHITE	101100	+0030.06	-0029.97	030.0	+0028.00	+0000.
WHITE	101200	+0030.07	-0029.97	030.0	+0042.00	+0000.
WHITE	101300	+0030.07	-0029.96	030.0	+0042.00	+0000.
WHITE	101400	+0030.08	-0029.95	030.0	+0042.00	+0000.
WHITE	101500	+0030.08	-0029.95	030.0	+0042.00	+0000.
WHITE	101600	+0030.09	-0029.94	030.0	+0060.00	+0000.
WHITE	101700	+0030.09	-0029.93	030.0	+0060.00	+0000.
WHITE	101800	+0030.10	-0029.92	030.0	+0060.00	+0000.

Referee: Gets position information for DD for times between 0956 and 1018. (Later times next page.)

POS/RED+OWN/=0956/=0958/=1000/=1001/=1002/  
 =1003/=1004/=1005/=1006/=1007/=1008/=1009/=1010/=1011/  
 =1012/=1013/=1014/=1015/=1016/=1017/=1018

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
THE TIME	095600	OCCURS BEFORE THE GAME BEGAN				
OORED	095800	+0030.15	-0029.85	005.0	+0135.00	+0100.
OORED	100000	+0030.15	-0029.85	005.0	+0135.00	+0100.
OORED	100100	+0030.15	-0029.85	005.0	+0135.00	+0100.
OORED	100200	+0030.15	-0029.85	005.0	+0135.00	+0100.
OORED	100300	+0030.14	-0029.84	010.0	TURN	+0100.
OORED	100400	+0030.14	-0029.85	010.0	TURN	+0100.
OORED	100500	+0030.14	-0029.85	015.0	-0093.00	+0100.
OORED	100600	+0030.14	-0029.85	015.0	-0093.00	+0100.
OORED	100700	+0030.14	-0029.86	015.0	-0093.00	+0100.
OORED	100800	+0030.14	-0029.86	015.0	-0093.00	+0100.
OORED	100900	+0030.14	-0029.87	015.0	-0141.00	+0100.
OORED	101000	+0030.14	-0029.87	015.0	-0141.00	+0100.
OORED	101100	+0030.13	-0029.87	015.0	-0141.00	+0100.
OORED	101200	+0030.13	-0029.88	015.0	-0141.00	+0100.
OORED	101300	+0030.13	-0029.88	015.0	-0141.00	+0100.
OORED	101400	+0030.12	-0029.88	015.0	-0141.00	+0100.
OORED	101500	+0030.12	-0029.89	015.0	-0095.00	+0100.
OORED	101600	+0030.12	-0029.89	015.0	TURN	+0100.
OORED	101700	+0030.12	-0029.89	015.0	+0110.00	+0100.
OORED	101800	+0030.12	-0029.88	015.0	+0110.00	+0100.

Referee: Gets true position of SS for same times as above.

POS/WHITE+OWN/=1019/=1020/  
 =1021/=1022/=1023/=1024/=1025/=1026/=1027/=1028/=1029/  
 =1030/=1031/=1032/=1034/=1036/=1038/=1040/=1042/=1044

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH	
WHITE	101900	+0030.10	-0029.91	030.0	+0060.00	+0000.	
WHITE	102000	+0030.10	-0029.91	025.0	TURN	+0000.	
WHITE	102100	+0030.10	-0029.90	020.0	+0100.00	+0000.	Referee: Gets true position of DD for times greater than 1018. (For earlier times see preceding page.)
WHITE	102200	+0030.10	-0029.89	020.0	+0100.00	+0000.	
WHITE	102300	+0030.10	-0029.89	020.0	+0100.00	+0000.	
WHITE	102400	+0030.10	-0029.88	020.0	+0100.00	+0000.	
WHITE	102500	+0030.10	-0029.87	020.0	+0100.00	+0000.	
WHITE	102600	+0030.10	-0029.87	020.0	+0100.00	+0000.	
WHITE	102700	+0030.10	-0029.86	020.0	+0100.00	+0000.	
WHITE	102800	+0030.10	-0029.85	020.0	+0100.00	+0000.	
WHITE	102900	+0030.10	-0029.85	020.0	+0100.00	+0000.	
WHITE	103000	+0030.10	-0029.84	020.0	+0100.00	+0000.	
WHITE	103100	+0030.10	-0029.84	020.0	+0100.00	+0000.	
WHITE	103200	+0030.09	-0029.83	020.0	+0100.00	+0000.	
WHITE	103400	+0030.09	-0029.82	020.0	+0100.00	+0000.	
WHITE	103600	+0030.09	-0029.80	020.0	+0100.00	+0000.	
WHITE	103800	+0030.09	-0029.79	020.0	+0100.00	+0000.	
WHITE	104000	+0030.09	-0029.78	020.0	+0100.00	+0000.	
WHITE	104200	+0030.08	-0029.77	020.0	+0100.00	+0000.	
WHITE	104400	+0030.08	-0029.75	020.0	+0100.00	+0000.	

POS/RED+OWN/=1019/=1020/  
 =1021/=1022/=1023/=1024/=1025/=1026/=1027/=1028/=1029/  
 =1030/=1031/=1032/=1034/=1036/=1038/=1040/=1042/=1044

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH	
OORED	101900	+0030.11	-0029.88	015.0	+0110.00	+0100.	
OORED	102000	+0030.11	-0029.88	015.0	TURN	+0100.	Referee: Gets true position of SS for same times as above.
OORED	102100	+0030.11	-0029.88	015.0	-0120.00	+0100.	
OORED	102200	+0030.11	-0029.88	015.0	-0120.00	+0100.	
OORED	102300	+0030.10	-0029.89	015.0	-0120.00	+0100.	
OORED	102400	+0030.10	-0029.89	015.0	-0120.00	+0100.	
OORED	102500	+0030.10	-0029.90	015.0	-0120.00	+0100.	
OORED	102600	+0030.10	-0029.90	015.0	-0120.00	+0100.	
OORED	102700	+0030.10	-0029.90	015.0	-0120.00	+0100.	
OORED	102800	+0030.09	-0029.91	015.0	-0120.00	+0100.	
OORED	102900	+0030.09	-0029.91	015.0	-0120.00	+0100.	
OORED	103000	+0030.09	-0029.92	015.0	-0120.00	+0100.	
OORED	103100	+0030.09	-0029.92	015.0	-0120.00	+0100.	
OORED	103200	+0030.09	-0029.93	015.0	-0120.00	+0100.	
OORED	103400	+0030.08	-0029.93	015.0	-0120.00	+0100.	
OORED	103600	+0030.08	-0029.94	015.0	-0120.00	+0100.	
OORED	103800	+0030.07	-0029.95	015.0	-0120.00	+0100.	
OORED	104000	+0030.07	-0029.96	015.0	-0120.00	+0100.	
OORED	104200	+0030.07	-0029.97	015.0	-0120.00	+0100.	
OORED	104400	+0030.06	-0029.98	015.0	-0120.00	+0100.	

### 3.3 Game Three

In the third game, a CVS attempts to maintain a course of  $0^{\circ}$  in order to reach its destination but upon detecting a submarine, is forced to increase its speed and to change course.

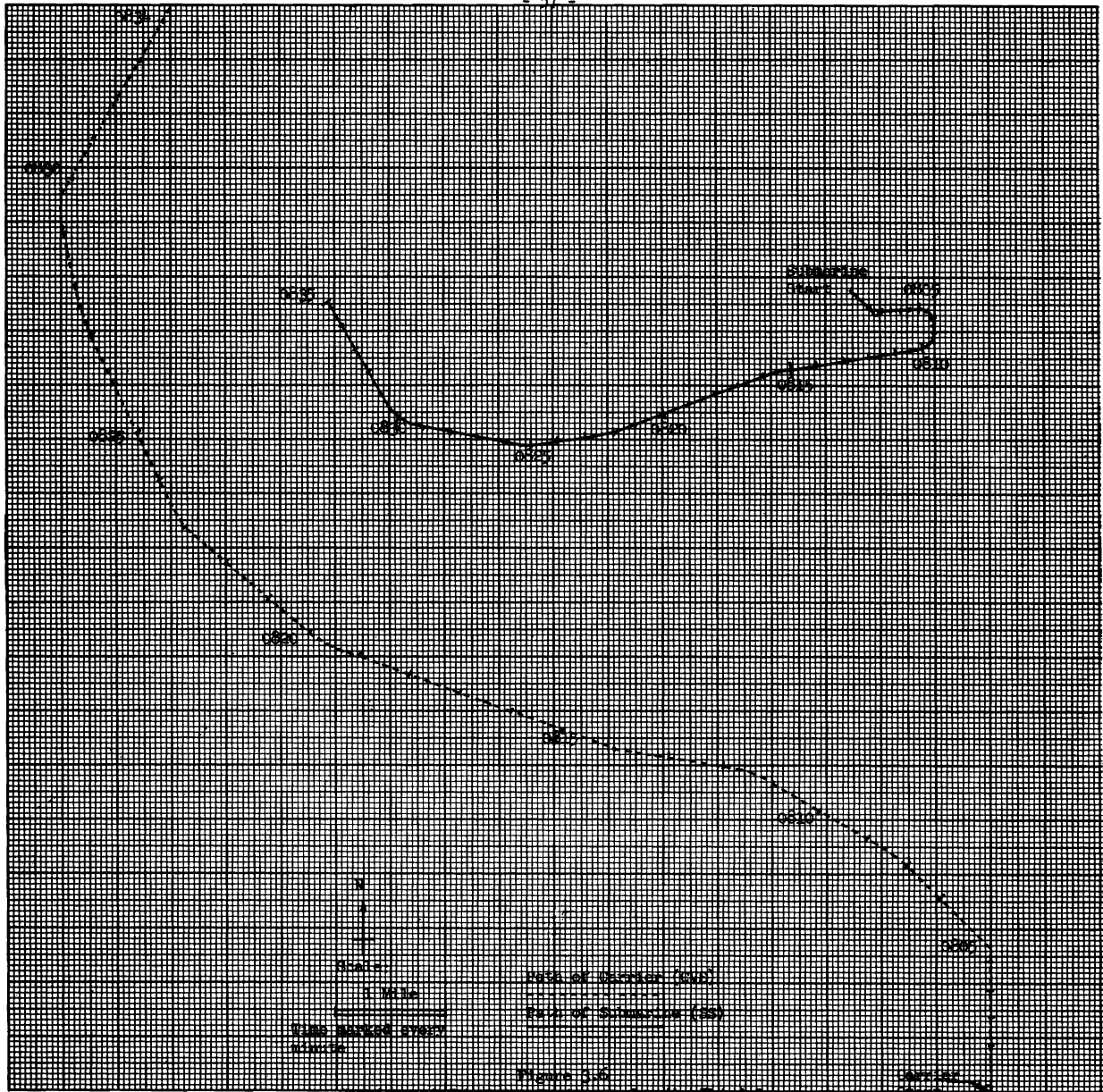
Figure 3.6 shows the maneuvers made by the CVS. By 08:30 the CVS has successfully evaded the submarine and can return towards its initial destination.

Figure 3.7 shows that the range between the two ships is always greater than three miles (torpedo range is 2.25 miles) and actually remains fairly constant at about three to four miles after 08:10.

An annotated listing of this game is now given.

<u>Functions</u>	<u>Page Number</u>
Initial Positions and Sailing Plan of Both Players	59
Commands and Queries Made By the CVS Captain	60
Commands and Queries Made By the SS Captain	66
Functions Used By the Referee	72





Carrier and Submarine Positions for the Third Game

5000

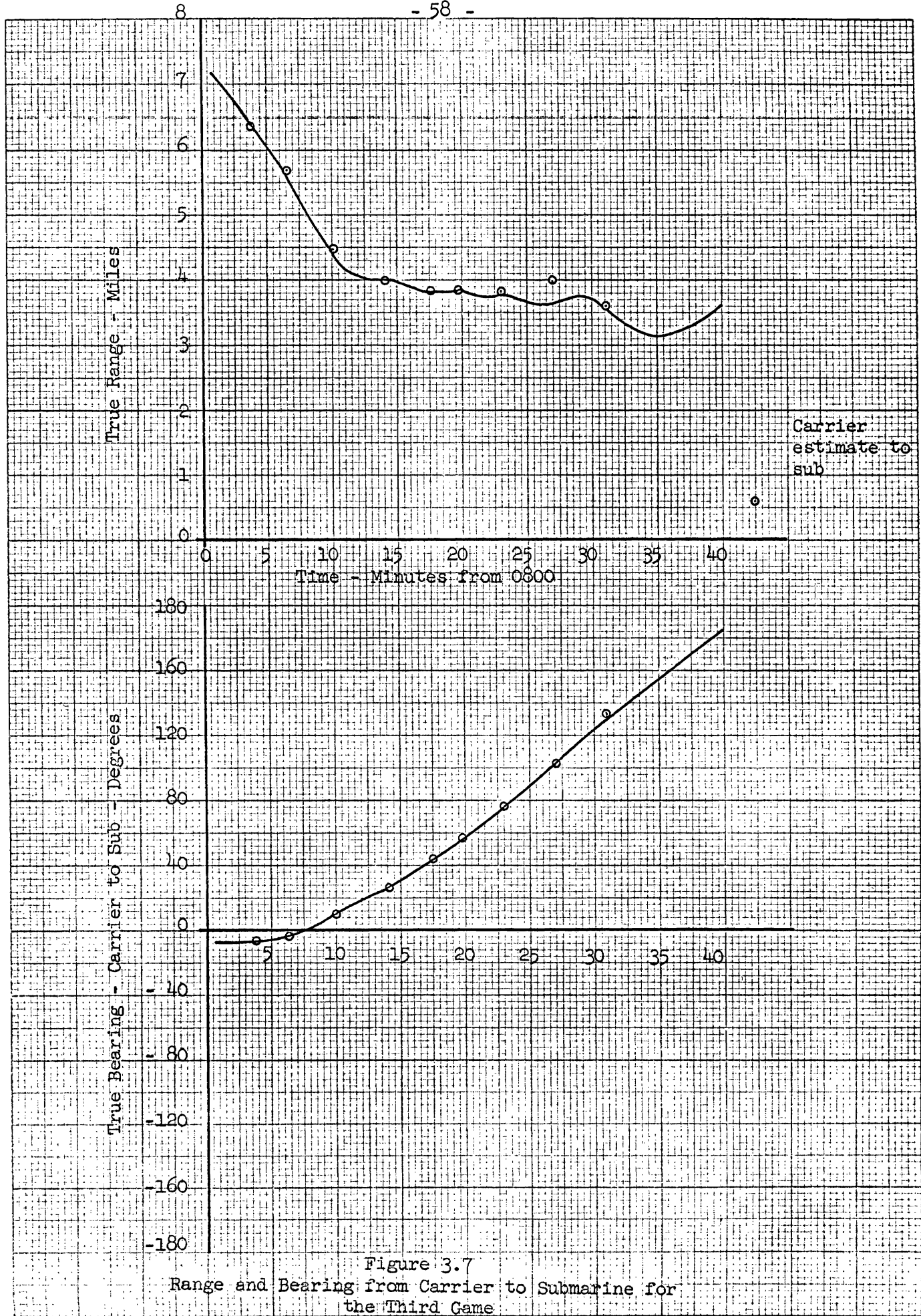


Figure 3.7  
Range and Bearing from Carrier to Submarine for  
the Third Game

Initial Positions and Sailing Plans of Both Players

---

INTLZ  
INTLZ WAS ENTERED

---

Initializes game.

---

START/RED+OWN/=30.12/=-30.02/WHITE+OWN/=30/=-30  
INITIAL POSITION HAS BEEN STORED FOR TIME = 080015

---

Sets initial position of both ships  
Submarine 30.12°N 30.02°W  
Carrier 30°N 30°W

---

SETSP/RED+OWN/=5/=85/=100/=30/=5/=130/=100/=30/  
=5/=85/=100/=30/=5/=40/=100/=30/=5/=85/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 080025

---

Initial sailing plan of Sub(SS) started

<u>Speed</u>	<u>Course</u>	<u>Depth</u>	<u>Duration</u>
5 Knots	85°	100 feet	30 Min.
5	130	100	30
5	85	100	30
5	40	100	30
5	85	100	Not Specified

---

SETSP/WHITE+OWN/=15/=0  
THE SAILING PLAN HAS BEEN STARTED TIME= 080032

---

Initial sailing plan of Carrier(CVS) started

<u>Speed</u>	<u>Course</u>	<u>Duration</u>
15 Knots	0°	Not Specified

---

Commands and Queries Made by the CVS Captain

---

USES/WHITE+ACT1+STEP/=1/=4  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

CVS: Take sonar readings at 1 minute intervals  
starting immediately.

---

USES/WHITE+ACT2/=0804/=0805/=0806/=0807  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

CVS: Take sonar readings between 0804 and 0807  
at indicated times.

---

USES/WHITE+ACT3/=0808/=0809/=0810/=0811  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

CVS: Requests that sonar readings be taken during  
interval 0808 to 0811.

---

USES/WHITE+ACT4/=0812/=0813/=0814/=0815  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

CVS: Requests more advance sonar readings.

---

USES/WHITE+ACT5/=0816/=0817/=0818/=0819  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

CVS: Requests more advance sonar readings for  
times between 0816 and 0819.

---

USES/WHITE+ACT6/=0820/=0821/=0822/=0823  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

CVS: Requests more advance sonar readings.

---

ESTOP/ACT1/SUB1  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 080039 AND 080239  
OPPONENT GOING +0005. KNOTS ON COURSE +0085.

---

CVS: First estimate of SS course and speed based on  
SONAR item ACT1 (previously requested) and creates  
an estimated sailing plan (SUB1). (Note: Estimate  
is correct as given.)

---

OPINT/SUB1/=15

---

IF RIVAL TRAVELS AT +0015. KNOTS,  
INTERCEPTION IN +0013. MINUTES AT 081637 CRSE=+0166.

---

CVS: If CVS continues on present sailing plan the SS can intercept at 081637 if SS changes to the indicated speed, course. (Based on estimated sailing plan SUB1.)

---

RANGE/WHITE+OWN/SUB1

---

RANGE = +0006.390000 BEARING = -0006. AT TIME = 080345

---

CVS: Based on ESTO item SUB1 the present range and bearing from CVS to SS is as given.

---

SETSP/WHITE+OWN/=25/=-45

---

THE SAILING PLAN HAS BEEN STARTED TIME= 080454

---

CVS: Sets new sailing plan to evade SS by passing behind SS, based on results of OPINT and range on ESTO item SUB1.

---

ESTDP/ACT2/SUB2

---

INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 080400 AND 080600  
OPPONENT GOING +0000. KNOTS ON COURSE +0109.

---

CVS: Based on later sonar readings a new estimate of course and speed of SS is given. (Note: SS is in a turn from 85° to 180°.)

---

RANGE/WHITE+OWN/SUB2

---

RANGE = +0005.680000 BEARING = -0004. AT TIME = 080614

---

CVS: Based on second estimate of SS course and speed (SUB2) the present range and bearing are as given.

---

OPINT/SUB2/=15

---

NO POSSIBLE INTERCEPTION AT THIS SPEED.

---

CVS: Due to change in CVS sailing plan the SS is unable to intercept at its max. speed of 15 Knots.

---

SETSP/WHITE+OWN/=30/=-60

---

THE SAILING PLAN HAS BEEN STARTED TIME= 080811

---

CVS: Comes to full speed and turns left 15° as a response to a change in estimated SS sailing plan.

---

---

ESTOP/ACT3/SUB3

---

INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 080800 AND 080900  
OPPONENT GOING +0005. KNOTS ON COURSE +0180.

---

CVS: Gets estimate of SS sailing plan based on third set of sonar readings. (Note: SS is on course and speed indicated.)

---

RANGE/WHITE+OWN/SUB3

---

RANGE = +0004.460000 BEARING = +0013. AT TIME = 080956

---

CVS: Gets estimate of current range and bearing to SS.

---

OPINT/SUB3/=15

---

NO POSSIBLE INTERCEPTION AT THIS SPEED.

---

CVS: Finds that SS still is unable to intercept.

---

SETSP/WHITE+OWN/=30/=-80

---

THE SAILING PLAN HAS BEEN STARTED TIME= 081115

---

CVS: Turns 20° to the left to increase range.

---

ESTOP/ACT4/SUB4

---

INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 081200 AND 081300  
OPPONENT GOING +0015. KNOTS ON COURSE -0100.

---

CVS: Obtains fourth estimate of SS sailing plan. (Note: SS has noted CVS evasion and turned west at maximum speed in an attempt to intercept.)

---

RANGE/WHITE+OWN/SUB4

---

RANGE = +0004.000000 BEARING = +0027. AT TIME = 081357

---

CVS: Gets current estimated range.

---

SETSP/WHITE+OWN/=30/=-70

---

THE SAILING PLAN HAS BEEN STARTED TIME= 081403

---

CVS: Changes course 10° to right since SS range and bearing estimates indicate evasion plan is proceeding satisfactorily and a return to original sailing plan can be started.

---

USES/WHITE+ACT7+STEP/=0.4/=4  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

CVS: Requests sonar readings be taken.

ESTOP/ACT7/SUB7  
ALL SENSOR READINGS TAKEN  
BASED ON +0004. READINGS BETWEEN 081549 AND 081701  
OPPONENT GOING +0015. KNOTS ON COURSE -0110.

CVS: Obtains fifth estimate of SS sailing plan.  
(Note: Estimate is correct as given.)

RANGE/WHITE+OWN/SUB7  
RANGE = +0003.820000 BEARING = +0044. AT TIME = 081731

CVS: Notes estimated bearing continues to increase satisfactorily  
and that range is relatively constant.

ESTOP/ACT5/SUB5  
ALL SENSOR READINGS TAKEN  
BASED ON +0004. READINGS BETWEEN 081600 AND 081900  
OPPONENT GOING +0015. KNOTS ON COURSE -0110.

CVS: Obtains sixth estimate of SS sailing plan.  
(Note: Estimate is same as fifth.)

RANGE/WHITE+OWN/SUB5  
RANGE = +0003.850000 BEARING = +0055. AT TIME = 081932

CVS: Obtains current range.

SETSP/WHITE+OWN/=30/=-50  
THE SAILING PLAN HAS BEEN STARTED TIME= 081937

CVS: Due to continued bearing increase CVS sets a more  
northerly sailing plan.

ESTOP/ACT6/SUB6  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 082000 AND 082200  
OPPONENT GOING +0015. KNOTS ON COURSE -0107.

CVS: Gets seventh estimate of SS sailing plan. (Note:  
SS is caught in turn from -110 to -100.)

RANGE/WHITE+OWN/SUB6

RANGE = +0003.790000 BEARING = +0076. AT TIME = 082256

CVS: Gets current range estimate.

SETSP/WHITE+OWN/=30/=-25

THE SAILING PLAN HAS BEEN STARTED TIME= 082302

CVS: Turns 25° further north since SS is nearly directly east of CVS.

USESN/WHITE+ACT8+STEP/=0.4/=4

SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

CVS: Gets another set of sonar readings at .4 minute intervals starting immediately.

ESTOP/ACT8/SUB8

ALL SENSOR READINGS TAKEN

BASED ON +0004. READINGS BETWEEN 082438 AND 082550

OPPONENT GOING +0003. KNOTS ON COURSE -0079.

CVS: Gets new estimate of SS sailing plan. (Note: SS is turning while sonar readings were made -- true speed is 15 Knots.)

USESN/WHITE+ACT9+STEP/=0.4/=4

SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

CVS: Gets the ninth set of sonar readings

RANGE/WHITE+OWN/SUB8

RANGE = +0003.960000 BEARING = +0103. AT TIME = 082659

CVS: Captain discovers he is north of SS.

SETSP/WHITE+OWN/=30/=-10

THE SAILING PLAN HAS BEEN STARTED TIME= 082719

CVS: Turns 15° further north.



---

SETSP/WHITE+OWN/=25/=30/=15/=20/=5/=10/=20/=0  
THE SAILING PLAN HAS BEEN STARTED TIME= 082918

---

CVS: Has evaded SS so new sailing plan is set to attain original objective. (Note that SS speed is reduced to 25 Knots for next 15 minutes.)

---

ESTOP/ACT9/SUB9  
ALL SENSOR READINGS TAKEN  
BASED ON +0004. READINGS BETWEEN 082705 AND 082817  
OPPONENT GOING +0015. KNOTS ON COURSE -0080.

---

CVS: Make ninth estimate of SS sailing plan. (Note: SS went to  $-70^{\circ}$  at 0829 and to  $-30^{\circ}$  at 0830.)

---

RANGE/WHITE+OWN/SUB9  
RANGE = +0003.590000 BEARING = +0133. AT TIME = 083056

---

CVS: Range and bearing indicate successful evasion.

---

Commands and Queries Made by the SS Captain

---

USES<sub>N</sub>/RED+SON<sub>1</sub>+STEP/=1/=4  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

SS: Take 4 sonar readings at 1 minute intervals starting immediately.

---

ESTOP/RED+SON<sub>1</sub>/CAR<sub>1</sub>  
INCOMPLETE SENSOR READINGS TAKEN  
BASED ON +0002. READINGS BETWEEN 080053 AND 080153  
OPPONENT GOING +0015. KNOTS ON COURSE -0000.

---

SS: First estimate of CVS course and speed based on SONAR item SON<sub>1</sub> (previously requested) and creates an estimated sailing plan (CAR<sub>1</sub>). (Note: CVS sailing plan is as given.)

---

INTER/RED+CAR<sub>1</sub>/=2  
IF YOU TRAVEL AT +0002. KNOTS,  
INTERCEPTION IN +0024. MINUTES AT 082757 CRSE=+0114.

---

SS: SS requests intercept course based on an SS speed of 2 Knots, if CVS remains on course and speed given in ESTO item CAR<sub>1</sub>.

---

RANGE/RED+OWN/CAR<sub>1</sub>  
RANGE = +0006.290000 BEARING = +0173. AT TIME = 080411

---

SS: Based on ESTO item CAR<sub>1</sub> the present range and bearing from SS to CVS is as given.

---

SETSP/RED+OWN/=5/=180/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 080518

---

SS: Sets new sailing plan to intercept CVS, based on RANGE and INTER on ESTO item CAR<sub>1</sub>.

---

USES<sub>N</sub>/RED+SON<sub>2</sub>+STEP/=.4/=3  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

SS: Requests 3 sonar readings to be taken at .4 minute intervals starting immediately.

---

ESTOP/RED+SON<sub>2</sub>/CAR<sub>2</sub>  
ALL SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 080524 AND 080612  
OPPONENT GOING +0022. KNOTS ON COURSE -0039.

---

SS: SS detects course and speed change of CVS using second set of sonar readings. (Note: CVS is changing from 15 Knots at 0° to 25 Knots at -45°. This change was initiated at 0805.)

---

RANGE/RED+OWN/CAR21  
RANGE = +0005.140000 BEARING = -0179. AT TIME = 080741

---

SS: Estimates current range and bearing based on second set of sonar readings.

---

INTER/RED+CAR21/=5  
NO POSSIBLE INTERCEPTION AT THIS SPEED.

---

SS: Using second estimate of CVS and an SS speed of 5 Knots, then no interception is possible for SS.

---

USESN/RED+SON22+STEP/=.4/=3  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

SS: Requests third set of sonar readings.

---

SETSP/RED+OWN/=15/=-100/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 080907

---

SS: Sets new sailing plan based on latest estimate of bearing and CVS sailing plan.

---

ESTOP/RED+SON22/CAR22  
ALL SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 080756 AND 080844  
OPPONENT GOING +0027. KNOTS ON COURSE -0053.

---

SS: Gets third estimate of CVS sailing plan. (Note: CVS changing sailing plan from +25 Knots at -45° to 30 Knots at -60° starting at 0808.)

---

RANGE/RED+OWN/CAR22  
RANGE = +0004.170000 BEARING = -0166. AT TIME = 081039

---

SS: Gets estimate of current range and bearing to CVS based on estimated sailing plan CAR22.

---

USESN/RED+SON23+STEP/=.4/=3  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

SS: Requests fourth set of sonar readings.

---

---

ESTOP/RED+SON23/CAR23

---

ALL SENSOR READINGS TAKEN

---

BASED ON +0003. READINGS BETWEEN 081046 AND 081134

---

OPPONENT GOING +0030. KNOTS ON COURSE -0064.

---

SS: Gets fourth estimate of CVS sailing plan.

---

RANGE/RED+OWN/CAR23

---

RANGE = +0003.840000 BEARING = -0156. AT TIME = 081250

---

SS: Obtains current estimate of range and bearing

---

INTER/RED+CAR23/=15

---

NO POSSIBLE INTERCEPTION AT THIS SPEED.

---

SS: Finds no interception with latest estimate of CVS sailing plan even at max. speed of 15 Knots.

---

USESN/RED+SON24+STEP/= .4/=3

---

SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

SS: Requests the fifth set of sonar readings.

---

ESTOP/RED+SON24/CAR24

---

ALL SENSOR READINGS TAKEN

---

BASED ON +0003. READINGS BETWEEN 081256 AND 081344

---

OPPONENT GOING +0030. KNOTS ON COURSE -0080.

---

SS: Gets fifth estimate of CVS sailing plan.

(Note: CVS course and speed correct as given, however, CVS went to  $-70^{\circ}$  at 0814.)

---

RANGE/RED+OWN/CAR24

---

RANGE = +0004.020000 BEARING = -0146. AT TIME = 081523

---

SS: Obtains current range estimate.

---

USESN/RED+SON25+STEP/= .4/=3

---

SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

SS: Requests that the sixth set of sonar readings be taken.

---

---

SETSP/RED+OWN/=15/=-110/=100

---

THE SAILING PLAN HAS BEEN STARTED TIME= 081542

---

SS: Changes sailing plan to try to close with CVS, based on previous range, bearing and estimated CVS sailing plan.

---

ESTOP/RED+SON25/CAR25

---

ALL SENSOR READINGS TAKEN

---

BASED ON +0003. READINGS BETWEEN 081529 AND 081617

---

OPPONENT GOING +0030. KNOTS ON COURSE -0070.

---

SS: Notes that CVS has made a turn towards north. (The carrier seems to desire to head in a northerly direction.)

---

RANGE/RED+OWN/CAR25

---

RANGE = +0003.810000 BEARING = -0131. AT TIME = 081812

---

SS: Gets current range.

---

USESN/RED+SON26+STEP/=.4/=3

---

SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

SS: Requests seventh set of sonar readings.

---

ESTOP/RED+SON26/CAR26

---

ALL SENSOR READINGS TAKEN

---

BASED ON +0003. READINGS BETWEEN 081818 AND 081906

---

OPPONENT GOING +0030. KNOTS ON COURSE -0070.

---

SS: The estimate using seventh set of sonar readings indicates that CVS has maintained the same sailing plan. (Note: CVS went to -50° at 081937.)

---

RANGE/RED+OWN/CAR26

---

RANGE = +0003.970000 BEARING = -0116. AT TIME = 082114

---

SS: Requests current range estimate.

---

USESN/RED+SON27+STEP/=.4/=3

---

SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

SS: Requests eighth set of sonar readings.

SETSP/RED+OWN/=15/=-100/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 082120

SS: Having detected CVS change towards north, modifies its own sailing plan in hope of maintaining contact.

ESTOP/RED+SON27/CAR27  
ALL SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 082041 AND 082129  
OPPONENT GOING +0030. KNOTS ON COURSE -0050.

SS: Obtains eighth estimate of CVS sailing plan. (Note: CVS plan is as given until 0823 when it becomes  $-25^{\circ}$ .)

RANGE/RED+OWN/CAR27  
RANGE = +0003.810000 BEARING = -0100. AT TIME = 082338

SS: Gets current range. Notes that CVS will soon be to the north.

USESN/RED+SON28+STEP/=.4/=3  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

SS: Gets another set of sonar readings.

SETSP/RED+OWN/=15/=-80/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 082501

SS: Changes sailing plan to head slightly north of west to maintain contact with CVS.

ESTOP/RED+SON28/CAR28  
ALL SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 082345 AND 082433  
OPPONENT GOING +0030. KNOTS ON COURSE -0025.

SS: Obtains ninth estimate of CVS sailing plan.  
(Note: Is correct as given.)

RANGE/RED+OWN/CAR28  
RANGE = +0003.640000 BEARING = -0080. AT TIME = 082618

SS: Get current range. Note that while range is lower than any previous estimate CVS is now slightly north of SS.

---

USES/RED+SON29+STEP/=.4/=3  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

SS: Requests tenth set of sonar readings.

---

ESTOP/RED+SON29/CAR29  
ALL SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 082623 AND 082711  
OPPONENT GOING +0030. KNOTS ON COURSE -0025.

---

SS: Gets new ESTOP. Note that there is no change from the previous estimate of CVS sailing plan. (Note: CVS went to  $-10^{\circ}$  at 082719.)

---

RANGE/RED+OWN/CAR29  
RANGE = +0003.860000 BEARING = -0065. AT TIME = 082847

---

SS: Gets current range. Notes range increasing again and CVS further north.

---

USES/RED+SON30+STEP/=.4/=3  
SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES

---

SS: Requests more sonar readings.

---

SETSP/RED+OWN/=15/=-70/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 082906

---

SS: Turns  $10^{\circ}$  further north.

---

SETSP/RED+OWN/=15/=-30/=100  
THE SAILING PLAN HAS BEEN STARTED TIME= 083000

---

SS: Turns  $40^{\circ}$  further north. Since CVS is so far to north and seems to be returning to  $0^{\circ}$  course as a game start SS decides to turn much more north.

---

ESTOP/RED+SON30/CAR30  
ALL SENSOR READINGS TAKEN  
BASED ON +0003. READINGS BETWEEN 082852 AND 082940  
OPPONENT GOING +0029. KNOTS ON COURSE -0005.

---

SS: Gets eleventh estimate of CVS sailing plan. (Note: CVS changed from 30 Knots at  $-10^{\circ}$  to 25 Knots at  $30^{\circ}$  at 082918.)

---

RANGE/RED+OWN/CAR30  
RANGE = +0003.990000 BEARING = -0046. AT TIME = 083208

---

SS: Notes range increasing further.

---

Functions Used by the Referee

RANGE/WHITE+OWN/RED+OWN/=0600/=1/=59

RANGE = +0000.000000	BEARING = +0000.	AT TIME = 080000
RANGE = +0007.090000	BEARING = -0007.	AT TIME = 080100
RANGE = +0006.830000	BEARING = -0007.	AT TIME = 080200
RANGE = +0006.580000	BEARING = -0007.	AT TIME = 080300
RANGE = +0006.330000	BEARING = -0006.	AT TIME = 080400
RANGE = +0006.070000	BEARING = -0006.	AT TIME = 080500
RANGE = +0005.750000	BEARING = -0004.	AT TIME = 080600
RANGE = +0005.380000	BEARING = -0000.	AT TIME = 080700
RANGE = +0005.010000	BEARING = +0002.	AT TIME = 080800
RANGE = +0004.690000	BEARING = +0007.	AT TIME = 080900
RANGE = +0004.400000	BEARING = +0012.	AT TIME = 081000
RANGE = +0004.160000	BEARING = +0016.	AT TIME = 081100
RANGE = +0004.040000	BEARING = +0019.	AT TIME = 081200
RANGE = +0004.010000	BEARING = +0023.	AT TIME = 081300
RANGE = +0004.000000	BEARING = +0027.	AT TIME = 081400
RANGE = +0003.940000	BEARING = +0032.	AT TIME = 081500
RANGE = +0003.880000	BEARING = +0036.	AT TIME = 081600
RANGE = +0003.830000	BEARING = +0041.	AT TIME = 081700
RANGE = +0003.810000	BEARING = +0047.	AT TIME = 081800
RANGE = +0003.830000	BEARING = +0052.	AT TIME = 081900
RANGE = +0003.840000	BEARING = +0057.	AT TIME = 082000
RANGE = +0003.770000	BEARING = +0064.	AT TIME = 082100
RANGE = +0003.750000	BEARING = +0070.	AT TIME = 082200
RANGE = +0003.780000	BEARING = +0076.	AT TIME = 082300
RANGE = +0003.700000	BEARING = +0083.	AT TIME = 082400
RANGE = +0003.640000	BEARING = +0090.	AT TIME = 082500
RANGE = +0003.630000	BEARING = +0097.	AT TIME = 082600
RANGE = +0003.680000	BEARING = +0104.	AT TIME = 082700
RANGE = +0003.710000	BEARING = +0110.	AT TIME = 082800
RANGE = +0003.750000	BEARING = +0118.	AT TIME = 082900
RANGE = +0003.710000	BEARING = +0125.	AT TIME = 083000
RANGE = +0003.540000	BEARING = +0130.	AT TIME = 083100
RANGE = +0003.390000	BEARING = +0136.	AT TIME = 083200
RANGE = +0003.290000	BEARING = +0142.	AT TIME = 083300
RANGE = +0003.210000	BEARING = +0148.	AT TIME = 083400
RANGE = +0003.180000	BEARING = +0154.	AT TIME = 083500
RANGE = +0003.190000	BEARING = +0161.	AT TIME = 083600
RANGE = +0003.250000	BEARING = +0167.	AT TIME = 083700
RANGE = +0003.340000	BEARING = +0174.	AT TIME = 083800
RANGE = +0003.460000	BEARING = +0179.	AT TIME = 083900
RANGE = +0003.620000	BEARING = -0174.	AT TIME = 084000

Game is over.  
The carrier  
has evaded  
the sub.  
Referee  
obtains the  
true range  
between  
players for  
the entire  
game.



PDS/WHITE+OWN/=0755/=0757/=0759/=0800/=0801/  
 =0802/=0803/=0804/=0805/=0806/=0807/=0808/=0809/=0810/  
 =0811/=0812/=0813/=0814/=0815/=0816

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
THE TIME	075500	OCCURS BEFORE THE GAME BEGAN				
THE TIME	075700	OCCURS BEFORE THE GAME BEGAN				
THE TIME	075900	OCCURS BEFORE THE GAME BEGAN				
THE TIME	080000	OCCURS BEFORE THE GAME BEGAN				
WHITE	080100	+0030.00	-0030.00	015.0	+0000.00	+0000.
WHITE	080200	+0030.01	-0030.00	015.0	+0000.00	+0000.
WHITE	080300	+0030.01	-0030.00	015.0	+0000.00	+0000.
WHITE	080400	+0030.02	-0030.00	015.0	+0000.00	+0000.
WHITE	080500	+0030.02	-0030.00	020.0	TURN	+0000.
WHITE	080600	+0030.02	-0030.00	025.0	-0045.00	+0000.
WHITE	080700	+0030.03	-0030.01	025.0	-0045.00	+0000.
WHITE	080800	+0030.03	-0030.01	025.0	-0045.00	+0000.
WHITE	080900	+0030.04	-0030.02	030.0	-0060.00	+0000.
WHITE	081000	+0030.04	-0030.03	030.0	-0060.00	+0000.
WHITE	081100	+0030.05	-0030.04	030.0	-0060.00	+0000.
WHITE	081200	+0030.05	-0030.05	030.0	-0080.00	+0000.
WHITE	081300	+0030.05	-0030.06	030.0	-0080.00	+0000.
WHITE	081400	+0030.05	-0030.07	030.0	-0080.00	+0000.
WHITE	081500	+0030.06	-0030.08	030.0	-0070.00	+0000.
WHITE	081600	+0030.06	-0030.08	030.0	-0070.00	+0000.

The referee also requests the positions of each ship at selected times.

PDS/RED+OWN/=0755/=0757/=0759/=0800/=0801/=0802/  
 =0803/=0804/=0805/=0806/=0807/=0808/=0809/=0810/=0811/  
 =0812/=0813/=0814/=0815/=0816/=0817/=0818

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
THE TIME	075500	OCCURS BEFORE THE GAME BEGAN				
THE TIME	075700	OCCURS BEFORE THE GAME BEGAN				
THE TIME	075900	OCCURS BEFORE THE GAME BEGAN				
THE TIME	080000	OCCURS BEFORE THE GAME BEGAN				
OORED	080100	+0030.12	-0030.02	005.0	+0085.00	+0100.
OORED	080200	+0030.12	-0030.02	005.0	+0085.00	+0100.
OORED	080300	+0030.12	-0030.02	005.0	+0085.00	+0100.
OORED	080400	+0030.12	-0030.01	005.0	+0085.00	+0100.
OORED	080500	+0030.12	-0030.01	005.0	+0085.00	+0100.
OORED	080600	+0030.12	-0030.01	005.0	TURN	+0100.
OORED	080700	+0030.12	-0030.01	005.0	TURN	+0100.
OORED	080800	+0030.12	-0030.01	005.0	+0180.00	+0100.
OORED	080900	+0030.12	-0030.01	005.0	+0180.00	+0100.
OORED	081000	+0030.11	-0030.01	015.0	-0100.00	+0100.
OORED	081100	+0030.11	-0030.02	015.0	-0100.00	+0100.
OORED	081200	+0030.11	-0030.02	015.0	-0100.00	+0100.
OORED	081300	+0030.11	-0030.03	015.0	-0100.00	+0100.
OORED	081400	+0030.11	-0030.03	015.0	-0100.00	+0100.
OORED	081500	+0030.11	-0030.04	015.0	-0100.00	+0100.
OORED	081600	+0030.11	-0030.04	015.0	-0110.00	+0100.
OORED	081700	+0030.11	-0030.04	015.0	-0110.00	+0100.
OORED	081800	+0030.11	-0030.05	015.0	-0110.00	+0100.

POS/WHITE+OWN/=0817/=0818/=0819/  
=0820/=0821/=0822/=0823/=0824/=0825/=0826/=0827/=0828/  
=0829/=0830/=0831/=0832/=0834/=0836/=0838/=0840/=0842

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
WHITE	081700	+0030.06	-0030.09	030.0	-0070.00	+0000.
WHITE	081800	+0030.06	-0030.10	030.0	-0070.00	+0000.
WHITE	081900	+0030.07	-0030.11	030.0	-0070.00	+0000.
WHITE	082000	+0030.07	-0030.12	030.0	-0050.00	+0000.
WHITE	082100	+0030.08	-0030.13	030.0	-0050.00	+0000.
WHITE	082200	+0030.08	-0030.14	030.0	-0050.00	+0000.
WHITE	082300	+0030.09	-0030.14	030.0	-0050.00	+0000.
WHITE	082400	+0030.09	-0030.15	030.0	-0025.00	+0000.
WHITE	082500	+0030.10	-0030.15	030.0	-0025.00	+0000.
WHITE	082600	+0030.11	-0030.16	030.0	-0025.00	+0000.
WHITE	082700	+0030.12	-0030.16	030.0	-0025.00	+0000.
WHITE	082800	+0030.12	-0030.16	030.0	-0010.00	+0000.
WHITE	082900	+0030.13	-0030.16	030.0	-0010.00	+0000.
WHITE	083000	+0030.14	-0030.16	025.0	+0030.00	+0000.
WHITE	083100	+0030.15	-0030.16	025.0	+0030.00	+0000.
WHITE	083200	+0030.15	-0030.16	025.0	+0030.00	+0000.
WHITE	083400	+0030.16	-0030.15	025.0	+0030.00	+0000.
WHITE	083600	+0030.18	-0030.14	025.0	+0030.00	+0000.
WHITE	083800	+0030.19	-0030.13	025.0	+0030.00	+0000.
WHITE	084000	+0030.20	-0030.12	025.0	+0030.00	+0000.
WHITE	084200	+0030.21	-0030.12	025.0	+0030.00	+0000.

More  
position  
informa-  
tion.

POS/RED+OWN/=0819/=0820/  
=0821/=0822/=0823/=0824/=0825/=0826/=0827/=0828/=0829/  
=0830/=0831/=0832/=0834/=0836/=0838/=0840/=0842/=0844

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
OORED	081900	+0030.11	-0030.05	015.0	-0110.00	+0100.
OORED	082000	+0030.10	-0030.06	015.0	-0110.00	+0100.
OORED	082100	+0030.10	-0030.06	015.0	-0110.00	+0100.
OORED	082200	+0030.10	-0030.07	015.0	-0100.00	+0100.
OORED	082300	+0030.10	-0030.07	015.0	-0100.00	+0100.
OORED	082400	+0030.10	-0030.08	015.0	-0100.00	+0100.
OORED	082500	+0030.10	-0030.08	015.0	-0100.00	+0100.
OORED	082600	+0030.10	-0030.09	015.0	-0080.00	+0100.
OORED	082700	+0030.10	-0030.09	015.0	-0080.00	+0100.
OORED	082800	+0030.10	-0030.10	015.0	-0080.00	+0100.
OORED	082900	+0030.10	-0030.10	015.0	-0080.00	+0100.
OORED	083000	+0030.10	-0030.10	015.0	-0070.00	+0100.
OORED	083100	+0030.11	-0030.11	015.0	-0030.00	+0100.
OORED	083200	+0030.11	-0030.11	015.0	-0030.00	+0100.
OORED	083400	+0030.12	-0030.11	015.0	-0030.00	+0100.
OORED	083600	+0030.13	-0030.12	015.0	-0030.00	+0100.
OORED	083800	+0030.13	-0030.12	015.0	-0030.00	+0100.
OORED	084000	+0030.14	-0030.13	015.0	-0030.00	+0100.
OORED	084200	+0030.15	-0030.13	015.0	-0030.00	+0100.
OORED	084400	+0030.15	-0030.14	015.0	-0030.00	+0100.

POS/WHITE+OWN/=0844/=0846/=0848/=0850/=0852/  
=0854/=0856/=0858/=0900/=0905/=0910

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
WHITE	084400	+0030.22	-0030.11	025.0	+0030.00	+0000.
WHITE	084600	+0030.24	-0030.10	020.0	+0005.00	+0000.
WHITE	084800	+0030.25	-0030.10	020.0	+0005.00	+0000.
WHITE	085000	+0030.26	-0030.10	020.0	+0005.00	+0000.
WHITE	085200	+0030.27	-0030.10	020.0	+0005.00	+0000.
WHITE	085400	+0030.28	-0030.10	020.0	+0005.00	+0000.
WHITE	085600	+0030.29	-0030.10	020.0	+0000.00	+0000.
WHITE	085800	+0030.30	-0030.10	020.0	+0000.00	+0000.
WHITE	090000	+0030.31	-0030.10	020.0	+0000.00	+0000.
WHITE	090500	+0030.34	-0030.10	020.0	+0000.00	+0000.
WHITE	091000	+0030.37	-0030.10	020.0	+0000.00	+0000.

Referee  
checks to  
see what  
happens  
to CVS if  
it follows  
sailing plan  
set just  
as game  
ended.

#### 4. SUMMARY AND EXTENSIONS

This report has described a man-machine game in which the competitors are the commander of a submarine and the captain of an opposing task force.

##### 4.1 Summary

Chapter 1 described the general structure of the game, cited salient features and introduced the functions (computer subprograms) which act as the members of a competitor's staff. As stated in Sect. 1.3 the game has conciseness of functional specification, immediacy of computer response and simultaneity of play. Further, the game is open-ended both in the accumulation of information in a specific duel and in the implementation of the game itself.

Chapter 2 further described the game and its environment by documenting the play of one competitor in a duel. Chapter 3 demonstrated the versatility of the game and the competitors' capability to interact with a computer by giving annotated output for three real-time games.

Appendix A reviews our experience in problem solving, while Appendix B describes our problem solving facility. Appendices C and D describe data structure and function subprograms in the game, respectively.

There are several roles the computer must assume during the play of a game. These roles are summarized below.

A. The computer system simulates the real life environment of the game and thus in fact keeps the game going. It simulates the motion of the various units and the information that may be collected by the sensors. The computer system collects this information and displays it to requesting players.

B. The computer system assumes the role of the various members of the crew, as was demonstrated in the documented duels. It may display speed and course (actual or assumed course of opponent) or project movements of units

at any future time including possible intercepts. It may give positions that occurred in the past or show sequences of readings of sensors.

C. The computer system serves as a repository for gathered or assumed information, which may be used for projecting movements into the future. Thus, a player may describe hypothetical situations and, with the aid of the computer, explore such hypotheses to resolve them and find the one that appears to him to be most likely.

D. The computer system also keeps a record of all the inquiries and decisions of each player and the conduct of the game for final evaluation at the end of the game.

In the next three sections we describe planned refinements to the game, extensions to general problem solving and suggest areas on which our methodology may have an impact.

#### 4.2 Planned Refinements to the Game

The documented duels in Chapter 3 demonstrate the prototype game's capability to interact with players in a real-time environment. However, there are refinements and elements to be added in the near future which will give the game a broader scope and higher degree of reality.

A prime consideration in the design of the game has been that it be modular so that extensions and refinements may be facilitated. Planned additions and refinements which will extend its capabilities and increase its realism are:

- a) a weapon model;
- b) an analyzer for passive sonar data;
- c) a random noise generator in the sonar models; and
- d) a graphic display capability

A. The prototype game does not have a weapon model. Clearly the introduction of a non-trivial weapon model would increase realism. Further, it would aid in the computer evaluation of a competitor's play in a game in which a "kill" is his goal. A weapon model is being implemented and is expected to be tested and operational by July 1968.

B. The techniques for analyzing passive sonar data in the real world are either analog or require a priori estimates of either the speed, course or range of the opponent. Difficulties were encountered in the implementation of an analyzer in which no estimates of the opponent were to be provided. Accordingly, a data analyzer which gives an estimate of an opponent's parameters based on a set of passive sonar readings and an estimate of either the speed or course of the opponent has been implemented and is expected to be tested and operational by July 1968.

C. Many difficulties with sonar readings in the real world arise because the sea near the surface is a non-homogeneous medium, full of bubbles, thermal gradients and other disturbances. Thus the introduction of random noise in sonar readings would give the game a higher degree of reality. The active and passive sonar models are being refined to include the generation of spurious readings and the introduction of random noise in readings. These refinements are expected to be tested and operational by July 1968.

D. A collection of sonar readings may include spurious readings, readings affected by noise and readings from several courses of the opponent. Hence, it is desirable for a player to be able to discriminate among the readings. This ability would be facilitated by a program which displays readings (points for active sonar data and rays for passive) on a geometric grid drawn on a CRT display unit. Such a program is being developed so that a player

will be able to request the display of sonar readings and then select those readings he wishes to be used in estimating the opponent's movements.

The incorporation of these additions and refinements will surely give the game a higher degree of reality and extend its scope.

#### 4.3 Planned Extensions to General Problem Solving

The general objective of our research has been to develop and experiment with methods of man-machine cooperation in Problem Solving. This competitive game has demonstrated how a human can construct a solution to a problem by defining and manipulating information modules and then selectively using them. This game could have wide implications to problem solving techniques. Two basic characteristics of such problem solving would be:

- (1) the real-time and dynamic interaction between the computer and the player
- (2) the design of the game in terms of basic modules from which complex solutions are built.

This game serves as a first step in our development of man-machine Problem Solving methodologies in which the computer not only takes action and provides information on demand but also actively assists in interpreting the problem itself. This will be done using the two basic structures of the game, information modules and program modules.

Information modules (or items) are created and modified at the request of the player who can thus store any data or results he thinks might be useful at some later time. In the next phase, a player will have the facility to merge various items containing estimates of his opponent's movements into one item. This will allow a player to eliminate conflicting sonar readings

and to fill in data where information is lacking. A player will be able to obtain several different possible merged items and then with further merging he could obtain the most probable sailing history of his opponent. This technique of continuously building up more complex structures will allow a player to start with simple estimates of speed and course over short time intervals and derive estimates of his opponent's maneuvers.

The basic program modules, or functions, are fixed and delimit the basic operations the computer can perform. The next step in our continuing research is to provide the player with the facility to define a hierarchical structure in which his problem solving strategies may be specified. When playing the game in its present form, a player specifies the functions he wishes executed. As a next step in complexity, a player will have the facility to combine various functions into procedures. Each procedure would consist of several functions together with parameters specifying the necessary items and data. The functions in a procedure could be executed either in succession or in any order determined by the parameters. The player will then have the capability to build more complex strategies by making sequences of procedures into higher-level procedures, and so on.

If a player finds it necessary to repeatedly execute several functions in succession, he may build a procedure out of these functions and thus simplify the play of the game. However, these procedures could ultimately become complicated maneuvers or tactics which a player designs as the game progresses. Such procedures could be stored for future games, and thus as his experience increases, a player could develop many strategies from which to choose.



The computer will also aid a player in developing tactics. When a difficult decision must be made, the computer could search for similar problems which have been stored and then give the player the tactics which were used in the past together with their results. Alternatively, the computer could develop several possible solutions. The player could then choose one or modify and merge several solutions into a tactic which he finds satisfactory.

Thus the player, together with aid from the computer, will be able to build ever more sophisticated solutions to his problems starting with the basic information and program modules of the game. This game serves as a vehicle in our development of problem solving methodologies as these techniques are general and could be applied to many problems.

#### 4.4 Recommendations

Although our research has been primarily directed towards the development of problem solving methods, it can have an impact on several closely related areas of interest to the Navy. We recommend that our methodology be investigated for use in:

- a) the development of tactics and strategies through war games;
- b) the training of commanding officers to use these tactics; and
- c) the development of integrated control systems.

A. The man-machine technology will have a considerable impact in the area of using war games for developing tactics and strategies. Currently developed games for this purpose, with very few exceptions, consist of simulating courses of action for which the parameters have been preset at the beginning of each game. Though such games are valuable in evaluating the effect of random factors on a preset situation, there is no provision

for changing decisions and parameters. In the real world, however, decisions are made moment by moment based on an evaluation of all past events, as well as on projections of specific possibilities. The gaming methodology that we are employing will provide the capability for developing strategies on a more realistic basis, where interim results may be evaluated and human input can be introduced at any stage of the game. Furthermore, based on the situation at any moment a player may adopt complex maneuvers which suit his specific goal, departing completely from any preset plan.

B. The new methodology will have a strong impact on the training of a commanding officer required to employ such strategies, for the game provides an ideal tool for placing him in an environment in which he must make decisions in real-time. Then at the end of the game the computer can produce a complete step-by-step evaluation of the opportunities he took advantage of and those he did not. Thus the computer evaluation helps monitor the progress of a trainee.

C. The methodology also serves as a foundation for the development of integrated control systems. In such a system the computer can make calculations and inform a commander in an operational environment what needs to be done. Moreover, the computer can on its own acquire information from the various sensors, perform the necessary analysis, make decisions on how to monitor the control mechanisms, then regulate them in such a way as to maintain optimum operation. Such a system may also enable a commander to use a CRT display, keyboard and light pen to effect changes in course, speed or depth (for submarines). Further, the system could enable him to request graphic displays of observed data to be used in estimating the movements of an opposing force.

We have cited but a few areas which may be affected by our research. The methodology may also prove useful in other areas of interest to the Navy, such as naval search procedures and oceanographic research.

APPENDIX A

REVIEW OF PROBLEM SOLVING RESEARCH AT THE UNIVERSITY OF PENNSYLVANIA

The human problem solving process has been a subject of study and writings since man began to regard himself introspectively. More recently, in connection with studies of artificial intelligence, more specific models of human problem solvings were devised.

The broad objectives of our research have been to develop, experiment with and demonstrate techniques for a very intimate participation between man and computer systems in the solution of day-to-day problems in a military or scientific environment. This research has been conducted since May 1963, with a number of phases completed, while other phases are on-going.

The research has been based on the basic premise that modern computer technology makes it feasible to augment human problem solving through supplying information and performing computations at speeds matching human thought.

It has been recognized that in order for the computer to provide such assistance it is necessary first to understand the nature of problem solving and find ways for interweaving man and machine problem solving steps. The weaving together of man/machine functions requires first a resolution of the following two problems:

- A. The dynamic organization (or continuous reorganization) of the information in the computer so that the human problem solver can readily and easily obtain what he needs.
- B. The communications by which the human problem solver can tell the machine, interactively, of the next step in the problem solution, and how the machine can react with responses including suggestions, information, and computations.

The problem solving methodology research at the Moore School has been concerned with the above problems and accordingly, the following research has been conducted:

A. Our first effort was to adapt the goal-subgoal attainment problem solving model, advanced by Newell, Simon and Shaw,<sup>[2]</sup> to include mass memory reorganization and man machine communication languages. This model of problem solving, on which our studies were based was described in a paper of Prywes.<sup>[3]</sup>

B. A computer program was developed whereby information could be selectively recalled or stored through associations developed in problem solution. The retrieval or storage can be accomplished at speeds matching human thought, using magnetic disk mass memory. This program has been described in a project report titled, A Storage and Retrieval System For Real-Time Problem Solving.<sup>[1]</sup>

C. A language was developed that can be used by a "non-programmer" by which he may describe, in a general way if necessary, the methods, resources, intelligence, etc., which he wants to employ in problem solution steps. Computer programs were developed which accept this language, interpret it and execute the requested retrievals, changes and computations. This language has been described in a project report titled, MULTILANG - An Executive System For Real-Time Problem Solving.<sup>[4]</sup>

D. Based on the Executive and Information Storage and Retrieval Systems described above, a problem solving facility was constructed where the human problem solver can communicate with a computer system and a well organized mass memory interactively from remote consoles. This development has been described in a project report titled, A Problem Solving Facility.<sup>[5]</sup>

To test this new methodology and make it attractive to the military personnel concerned with complex decisions, we have implemented this two-player competitive game based on an environment similar to that encountered by a commissioned officer.

The game was constructed by programming the game functions on the Problem Solving Facility whose hardware consists of the IBM 7040, connected through a satellite PDP-8 and high-speed telephone lines to remote consoles from which the competitors play the game. (See Appendix B for equipment configuration.)

## APPENDIX B

### THE EQUIPMENT CONFIGURATION

Figure B.1 illustrates the arrangement of the equipment used to play the game. The system includes an IBM 7040, which acts as the main computer, and a Digital Equipment Corp. (DEC) PDP-8 general purpose computer, which acts as the satellite computer, to monitor the Teletypes.

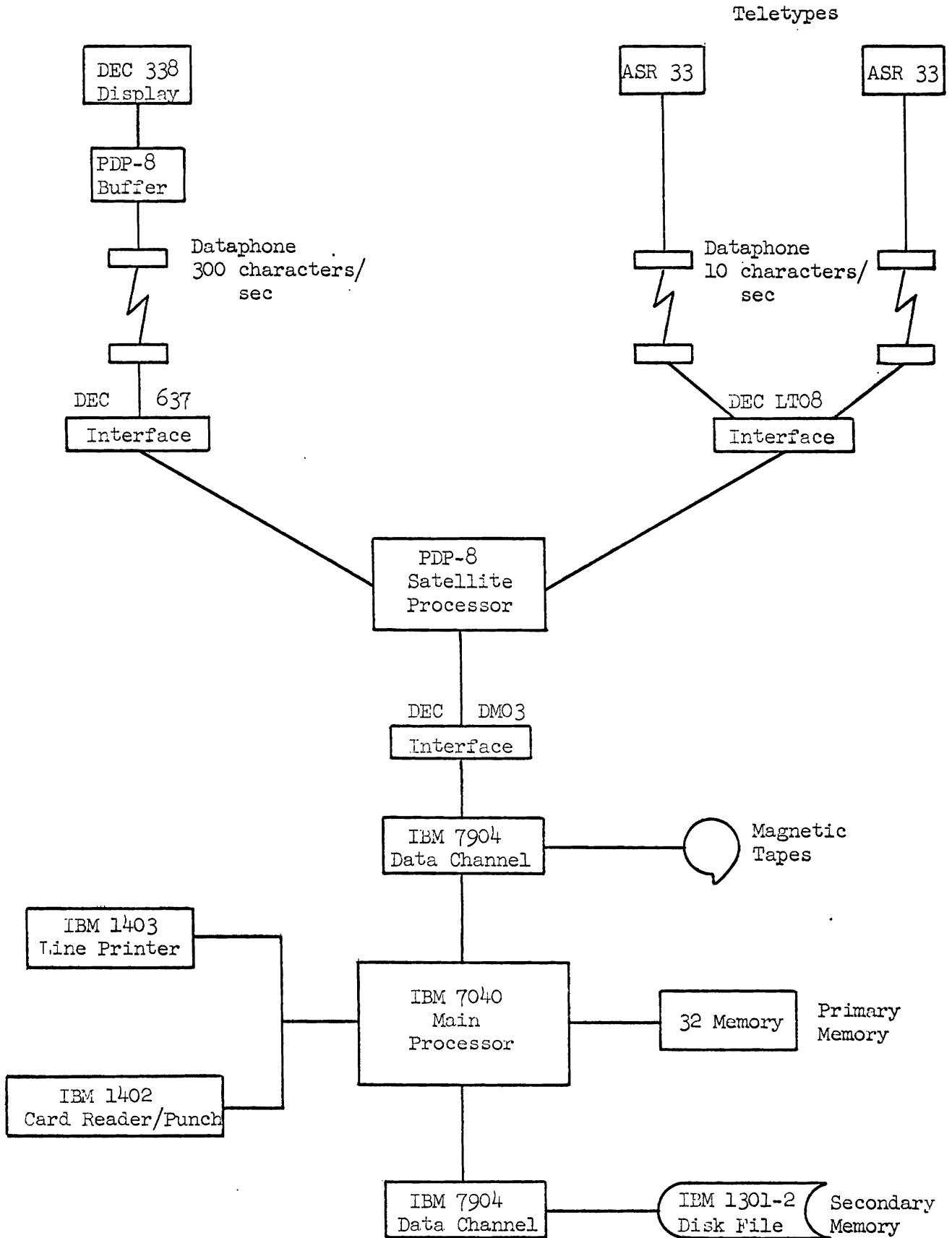
The main processor (IBM 7040) is a general purpose scientific machine with 32768 words of magnetic core memory. The following units are attached to the 7040 through appropriate Data Channels (IBM 7904's): a 1402 Card Reader/Punch; 1403 Line Printer; 1301-2 Disk File; 6 type 729II magnetic tape units; and the PDP-8 satellite processor.

The PDP-8 is a one address, fixed word length parallel computer using 12-bit two's complement arithmetic. One of the two PDP-8's used in the system acts as the satellite processor and the other as the buffering unit for a DEC 338 CRT display.

Two types of Dataphones are used in the system. Low speed Dataphones are used between the ASR-33 Teletypes and the PDP-8 satellite processing unit and a high speed Dataphone is used between the DEC 338, PDP-8 buffered display and the satellite unit.

A player's command to the system is passed from his Teletype to the satellite processor via a Dataphone and proper interface (DEC 637 or LTO8). After performing simple text handling operations, the satellite sends the information through an interfacing unit (DEC DMO3) to the main processor (IBM 7040). After processing, the system's reply to the player travels the same route. The information is transmitted from the 7040 through the interface to the PDP-8, where simple text handling may be performed, and then over telephone lines to the player.

Figure B.1 Equipment Configuration



## APPENDIX C

### STRUCTURE OF INFORMATION IN THE COMPUTER

The following is a description of the structure of data within the MULTILIST system for the game.<sup>[1]</sup> Each block of data is stored as an item on the disk. When a player desires to use an item, it is transferred from disk to core; thus, the high speed main memory contains only that information which is presently needed. This allows a player to store a large amount of information with little regard to the size of the computer memory.

All items are organized into an associative memory which consists of a directory of Keywords (also called Keys) organized in a tree structure. This directory is used to access lists corresponding to an association of Keywords. Records in both primary (core) and secondary (disk) memory are threaded by a list for each Keyword which is relevant to the record.

Effectively, the Keywords are the names given to each item. One refers to an item by using any collection of its names. By giving each item more than one name and by giving similar records at least one name in common, one can request and quickly obtain from the secondary memory the various records that are needed.

The data in each item is stored in elements. This is useful if one stores the same type of information in the same elements of different items. It is then possible to selectively retrieve parts of items and thus obtain only the information one needs. There are three types of items used by the player functions -- OWN, SONAR and ESTO.

#### C.1 OWN Items

Each player has his OWN item (Fig. C.1) in which is stored information describing his vessel, its equipment, its sailing history and plan. Pertinent characteristics which are to be used for identification are stored as Keys,



while a description of the vessel's equipment is stored in Elements 300 through 377.

Element 200 contains the position and velocity of the vessel for all times from the beginning of the game till that future time for which a sailing plan has been specified. Each time a vessel's velocity vector is changed, a block of information is added to Element 200. This block contains the ship's position at the time of change, the time, and the speed, course and depth assumed after the change.

### C.2 SONAR Items

A player may command the use of a sonar device to gather information about an opponent at specified times by referencing the function USESN (USE SeNsor). When such an order is given, USESN creates a SONAR item (Fig. C.2) which is to contain sonar readings made in real-time at the specified times.

### C.3 ESTO Items

A player may request an estimate of his opponent's location and course by referencing the function ESTOP (ESTimate OPponent). When such an order is given, ESTOP processes the data in the designated SONAR item. If sufficient data has accumulated for an analysis, ESTOP creates an ESTO item (Fig. C.3) which contains estimates of the opponent's position, speed and course.

FIGURE C.1 PLAYER'S OWN ITEM

KEY	ELEMENT	CONTENTS	COMMENT
1	1	SEALION	player's vessel name
2	2	SUB	type of vessel
3	3	RED	player's identification
4	4	OWN	
	200	44.02°N	position at start of game
		25.0°W	
		9:30	time game began
		10	speed, in knots
		40.0°E	course
		50	depth, in feet
		44.09°N	position at change
		24.93°W	of course
		9:59	time of change
		12.5	speed during change
		.0017°	turning radius in degrees
		50	depth
		44.09°N	position after change
		24.92°W	of course
		10:00	time when course change is completed
		15	speed after change
		168.0°E	course
		50	depth
		44.07°N	position at change
		24.92°W	of speed
		10:05	time of change
		10	speed
		168.0°E	course
		50	depth

FIGURE C.1 PLAYER'S OWN ITEM (cont.)

KEY	ELEMENT	CONTENTS	COMMENT
	300		Int. Radio Call Signal
	301		player's nationality
	302		max. speed, submerged
	303		cruising speed, submerged
	304		max. speed, surface
	305		cruising speed, surface
	306		max. depth in feet
	310		sensor equipment
	311		descr. of passive sonar
	312		descr. of active sonar
	313		descr. of radar
	320		name of weapons
	330		possible adversary ships
	340		endurance, submerged
	341		total endurance
	342		turning radius

FIGURE C.2 ACTIVE SONAR ITEM

KEY	ELEMENT	CONTENTS	COMMENT
1	1	ESSEX	player's vessel name
2	2	CVS	type of vessel
3	3	WHITE	player's name
4	4	ACTI	SONAR item name
5	5	ACTIVE	this is an active
6	6	SONAR	sonar item
7	7	SUB	type of opponent
	200	30.121N	carrier's position
		30.021W	at time of reading
		7:55	time of reading
		5.2°W	bearing of reading
		5	amplitude of reading
		30.010N	opponent's position
		30.001W	based on reading
-----			
		30.121N	own
		30.025W	position
		7:56	time
		4.1°W	bearing of reading
		5	amplitude of reading
		30.011N	opponent's
		30.001W	position
-----			
		:	
		:	
		:	

FIGURE C.3 ESTO ITEM

KEY	ELEMENT	CONTENTS	COMMENT
1	1	ESSEX	player's vessel name
2	2	CVS	type of vessel
3	3	WHITE	player's name
4	4	SUB1	ESTO item name
	200	24.943°N	estimated position .
		40.140°W	at $t_1$
		5:20	$t_1$
		10.0	estimated speed, in knots
		40.0°	estimated course
		24.965°N	estimated position
		40.160°W	at $t_n$
		5:30	$t_n$
	201	6	number of readings item based on

APPENDIX D

DESCRIPTION OF ROUTINES

The kernel of the game has been specified by seven player functions and three game initiation functions. The player functions were introduced in Sect. 1.2 and their usage was demonstrated in Chapters 2 and 3. Middle latitude sailing computations are used in all the player functions. That is, computations use the relations:

- |   |                         |
|---|-------------------------|
| 1) $D.Lat = (Lat.2 - Lat.1)$                          | Difference in latitude  |
| 2) $D.Lo = (Lo.2 - Lo.1)$                             | Difference in longitude |
| 3) $Mid.Lat = \left( \frac{Lat.1 + Lat.2}{2} \right)$ | Middle latitude         |
| 4) $Dep. = D.Lo * \cos(Mid. Lat.)$                    | Departure east or west  |
| 5) $Dist. = \sqrt{(D.Lat.)^2 + (Dep.)^2}$             | Distance                |
| 6) $\phi = \tan^{-1}(Dep./D.Lat)$                     | Course                  |

All the functions are computer routines which may be executed by specifying the appropriate MULTILANG statement at a remote console.<sup>[4]</sup>

This appendix contains write-ups and flowcharts for the seven player functions and write-ups for the three game initiation functions.

IDENTIFICATION: SETSP, Set Sailing Plan - A Player function

PURPOSE: To initiate a sequence of velocity vectors to be followed by a vessel.

USAGE: 1) SETSP/OWN item description/ $v_1/\phi_1/t_1/\dots/v_n/\phi_n/t_n$ ,  
for surface vessels.

2) SETSP/OWN item description/ $v_1/\phi_1/d_1/t_1/\dots/v_n/\phi_n/d_n/t_n$ ,  
for submarines.

where  $v_i$  - speed (knots)

$\phi_i$  - course (degrees)

$t_i$  - duration (minutes)

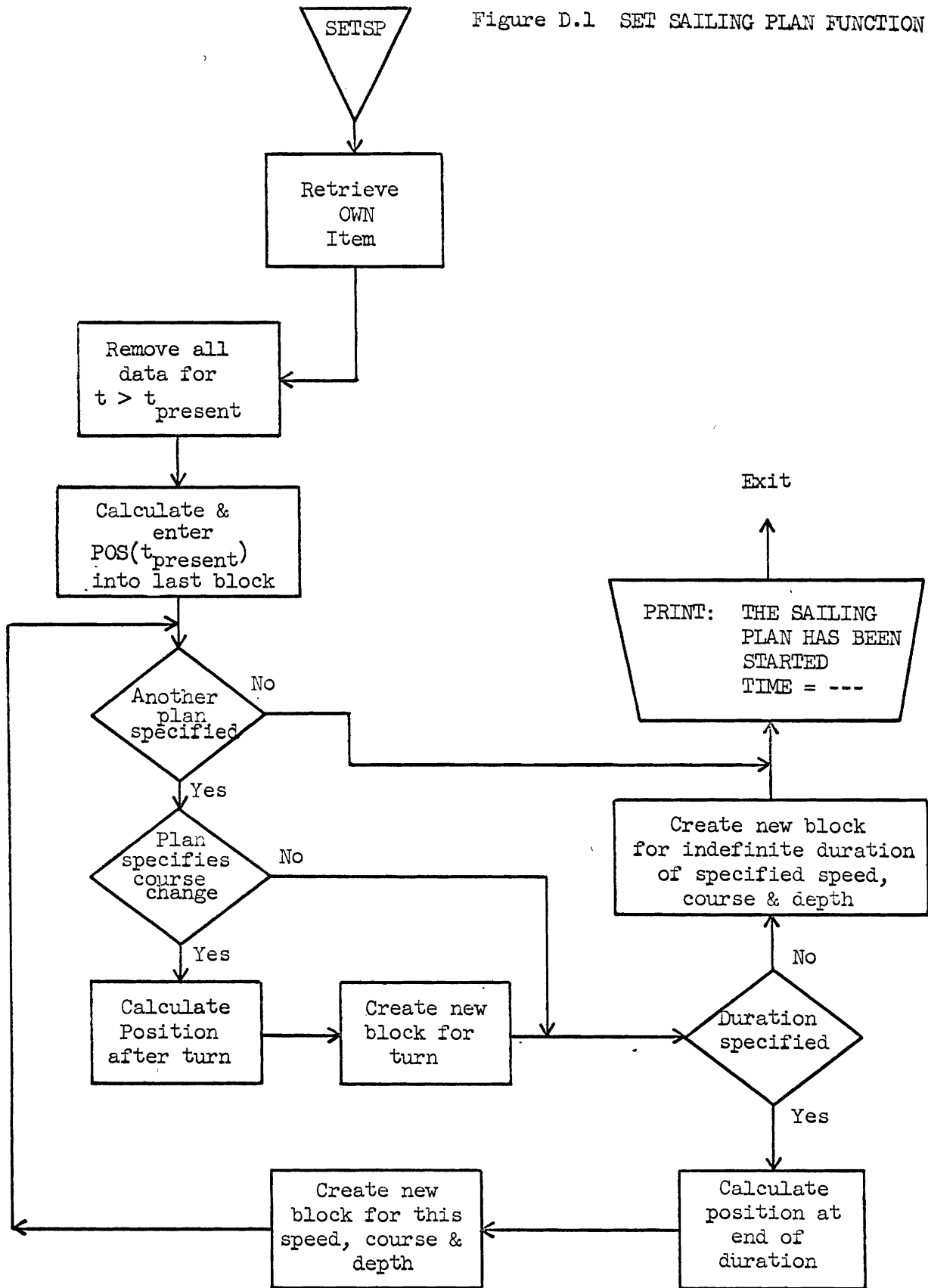
$d_i$  - depth (feet)

$t_n$  may be omitted if the duration is to be unspecified.

METHOD: SETSP inserts the specified velocity vectors beginning at the present time in the designated OWN item, overriding previously specified sailing plans.

ACTION: SETSP modifies the designated OWN item and prints the message -  
THE SAILING PLAN HAS BEEN STARTED TIME=tttttt

Figure D.1 SET SAILING PLAN FUNCTION



USAGE: 1) SETSP/OWN item description/speed/course/duration/...  
2) SETSP/OWN item description/speed/course/depth/duration/...



IDENTIFICATION: USESN, Use Sensor - A player function

PURPOSE: To make sensor observations at specified times.

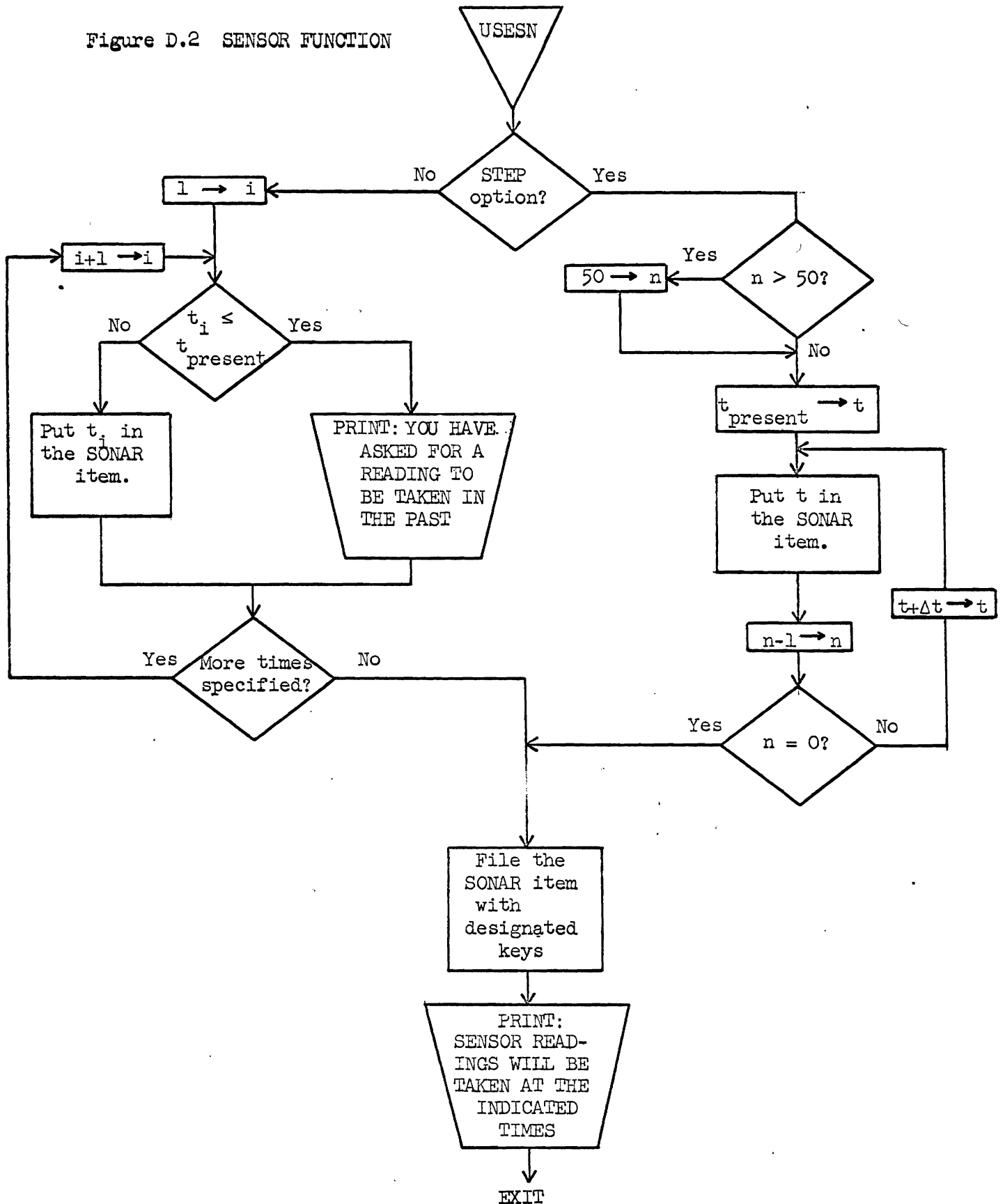
USAGE: 1) USESN/SONAR item description/ $t_1/t_2/...t_n$   
2) USESN/SONAR item description & STEP/ $\Delta t/n$   
(first reading at present time)

ACTION: USESN creates and stores a SONAR item, satisfying the specified description, which contains the specified times and prints the message - SENSOR READINGS WILL BE TAKEN AT THE INDICATED TIMES.

RESTRICTIONS:

- 1) USESN presently only initiates active and passive sonar readings.
- 2) Readings are not taken for times in the past; when a past time is requested, the player is informed, the time ignored and processing continues.
- 3) At most fifty readings may be put in a sensor record.
- 4) The times in usage 1) must be strictly increasing.

Figure D.2 SENSOR FUNCTION



USAGE: 1) USESN/SONAR item description/ $t_1/t_2/\dots/t_n$   
 2) USESN/SONAR item description & STEP/ $\Delta t/n$

IDENTIFICATION: ESTOP, Estimate Opponent - A player function

PURPOSE: To estimate the position, speed and course of an opponent.

USAGE: ESTOP/SONAR item description/ESTO item description

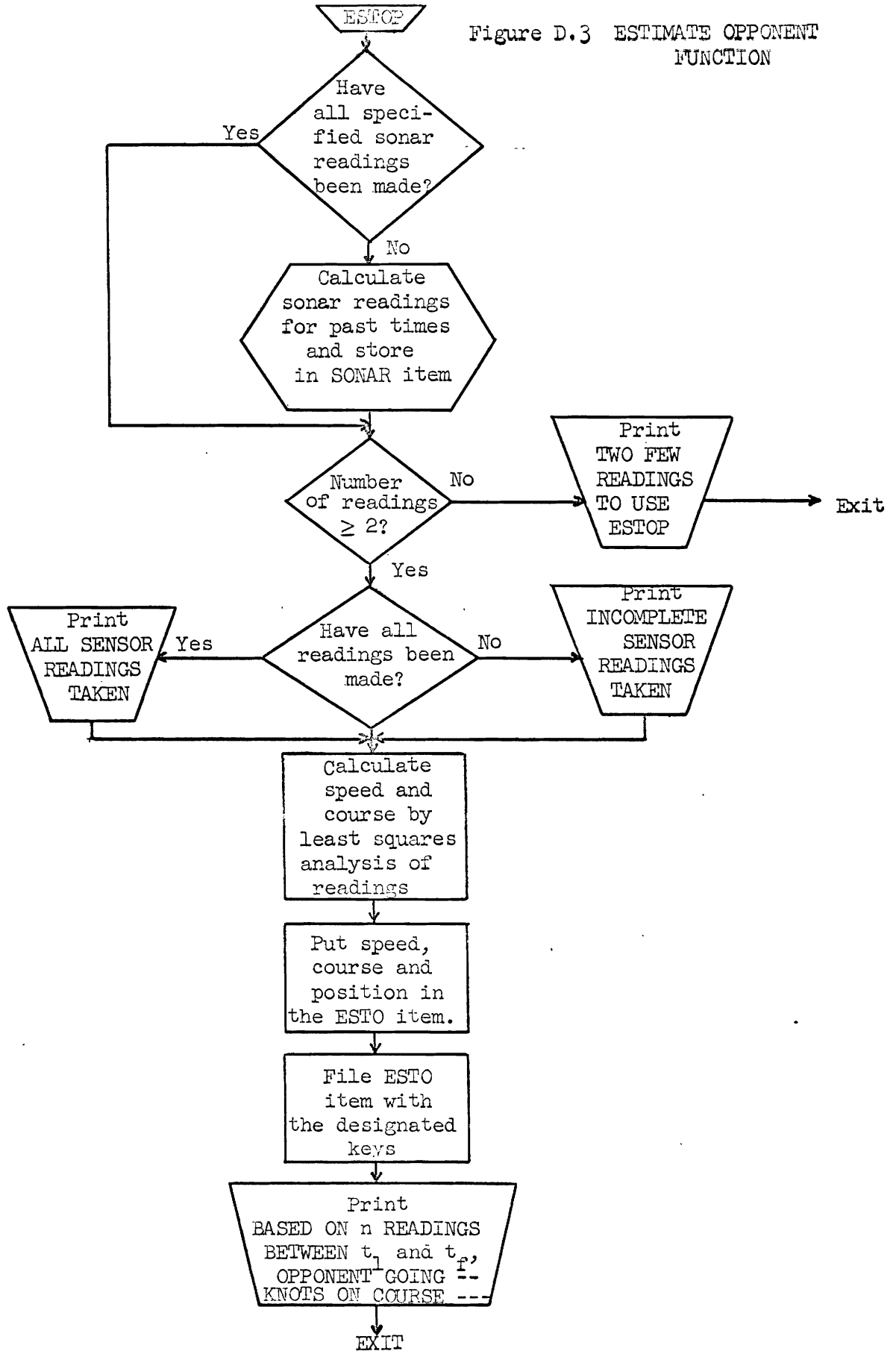
METHOD: ESTOP performs a least squares analysis of the readings in the designated SONAR item, then estimates the speed and course of the opponent.

ACTION: ESTOP obtains the positions of the vessels from the two OWN items for all past times specified in the SONAR item, then calculates and stores the sensor observations. ESTOP then takes one of two actions.

- 1) Creates and stores an ESTO item satisfying the prescribed description which contains estimates of the position, speed and course of the opponent; and prints the message - BASED ON n READINGS BETWEEN  $t_1$  and  $t_p$ , OPPONENT GOING mm KNOTS ON COURSE ppp.
- 2) Prints message -  
TOO FEW READINGS TO USE ESTOP.

RESTRICTION: ESTOP presently analyzes active sonar data only.

Figure D.3 ESTIMATE OPPONENT FUNCTION



USAGE: ESTOP/SONAR item description/ESTO item description

IDENTIFICATION: POS, Position - A player function

PURPOSE: To print the position, speed, course and depth of a vessel at specified times.

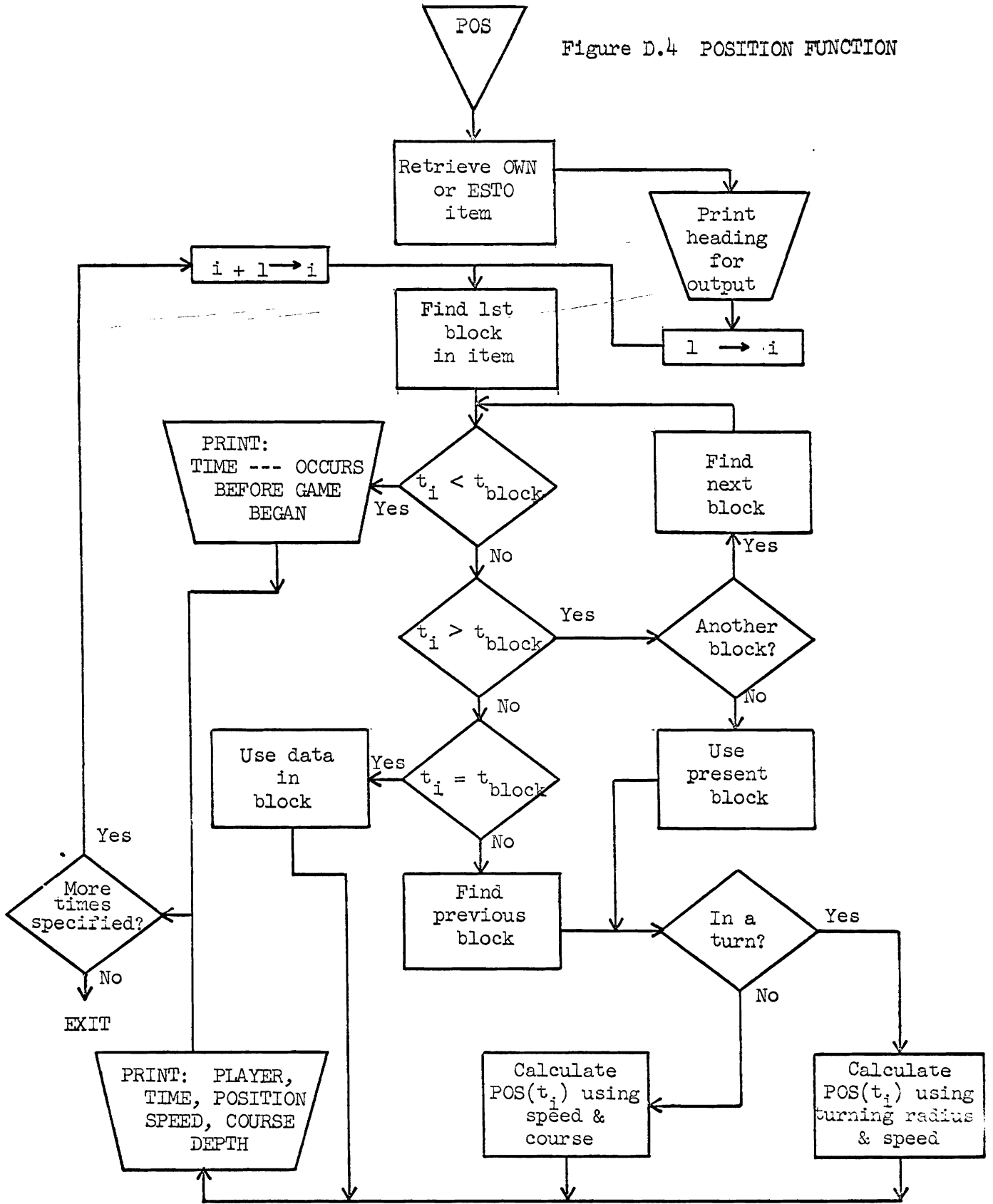
USAGE: 1) POS/OWN item description/ $t_1/t_2/.../t_n$   
2) POS/ESTO item description/ $t_1/t_2/...t_n$

METHOD: POS calculates the position at the specified times from the sailing plan stored in the designated item.

ACTION: Prints a table in the form -

PLAYER	TIME	LATITUDE	LONGITUDE	SPEED	COURSE	DEPTH
---	$t_1$	xxxx.xx	yyyy.yy	vv.v	cccc.cc	ddd.
:	:	:	:	:	:	:
---	$t_n$	xxxx.xx	yyyy.yy	vv.v	cccc.cc	ddd.

Figure D.4 POSITION FUNCTION



USAGE: POS/OWN or ESTO item description/ $t_1/t_2/.../t_n$

IDENTIFICATION: RANGE, Range of Opponent - A player function

PURPOSE: To estimate the range and true bearing of an opponent at specified times.

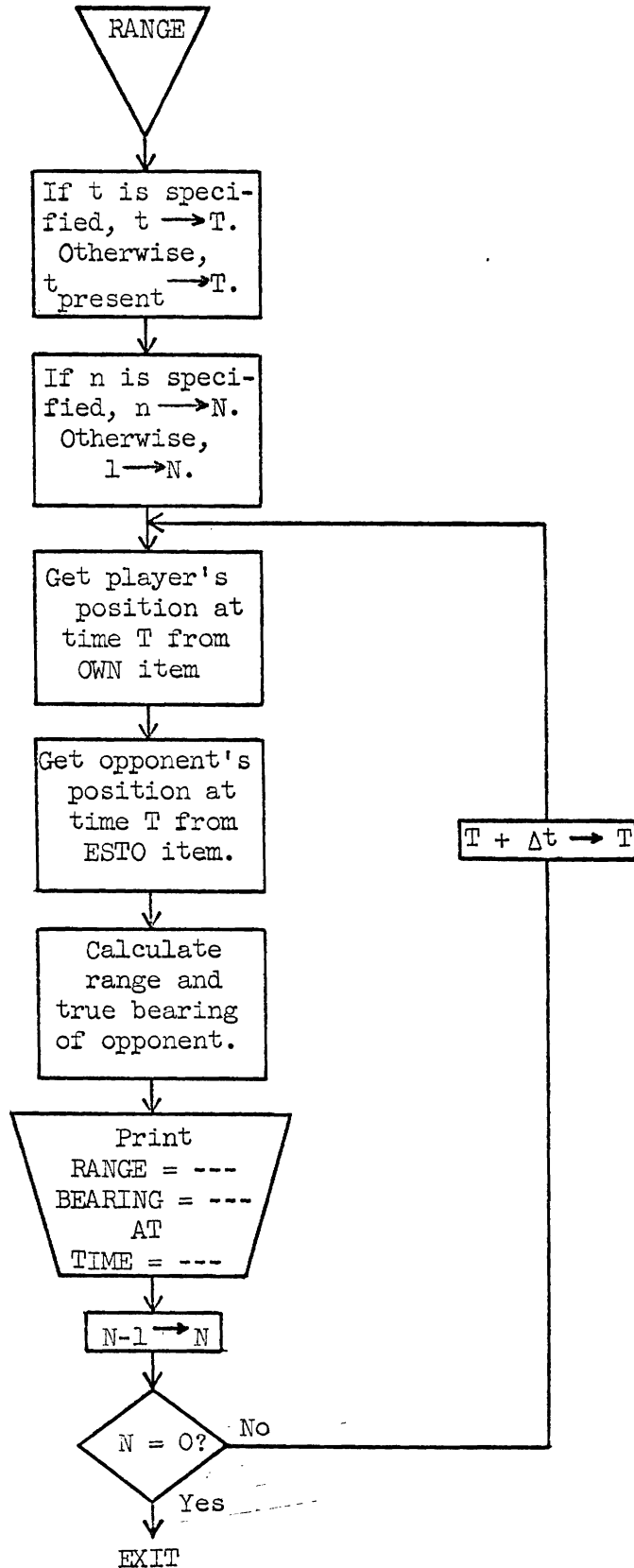
USAGE: 1) RANGE/OWN item description/ESTO item description/t  
2) RANGE/OWN item description/ESTO item description/t/ $\Delta$ t/n  
t may be omitted if present range is desired.

METHOD: RANGE obtains the position of the requesting player and an estimate of the opponent at the specified time(s) from the designated items, then calculates the range (n.m.) and true bearing (deg).

ACTION: Prints for each specified time the message -

RANGE = rrr.rr BEARING = bbbb. AT TIME = tttttt

Figure D.5 RANGE FUNCTION



USAGE: 1) RANGE/OWN item description/ESTO item description/t  
2) RANGE/OWN item description/ESTO item description/t/Δt/n



IDENTIFICATION: INTER, Find Interception Course - A player function

PURPOSE: To find an interception course for the pursuit of an opponent.

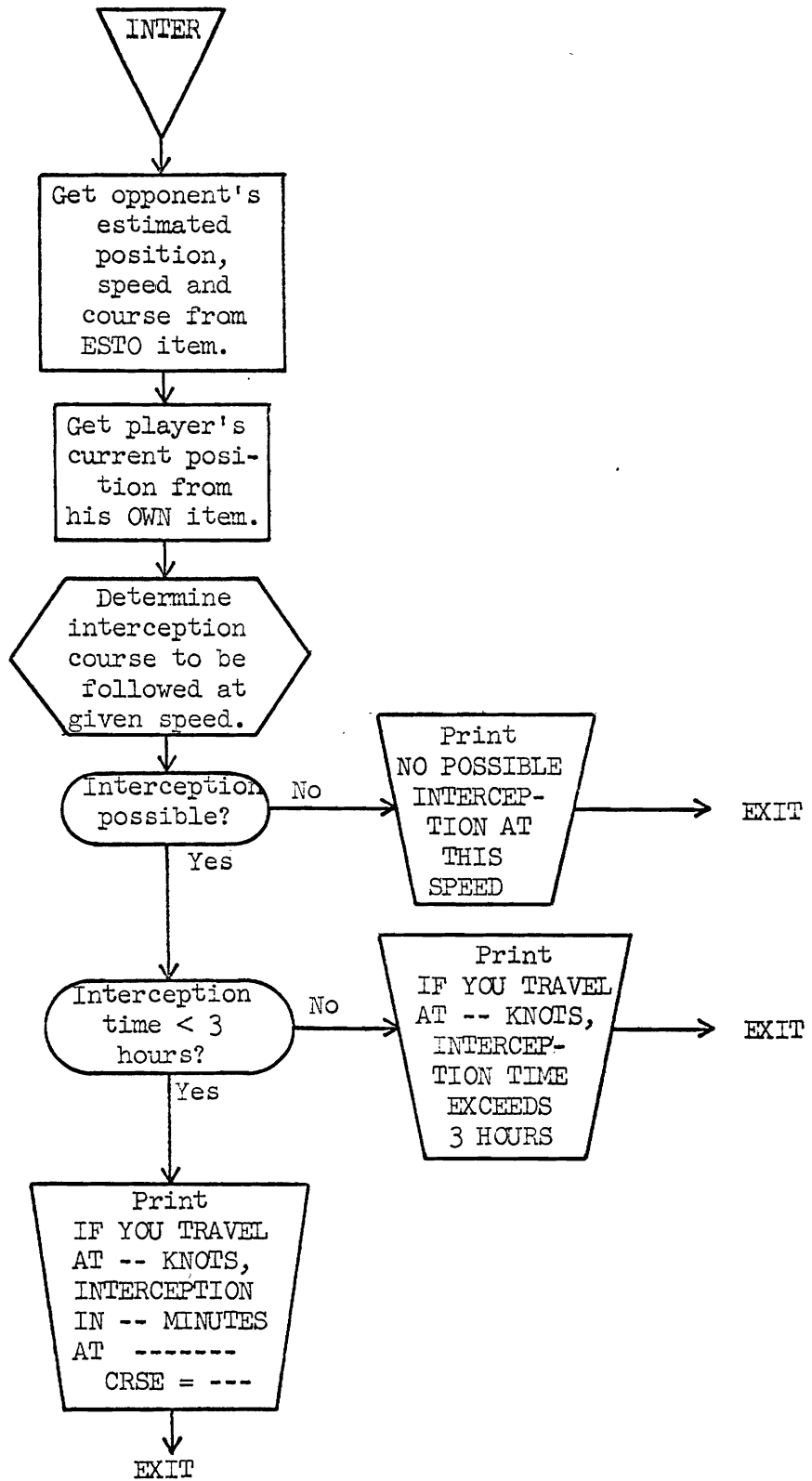
USAGE: INTER/ESTO item description/speed of interception

METHOD: INTER gets estimates of the opponent's present position, speed and course from the designated ESTO item and gets the requesting player's present position from his OWN item, then calculates the course to be followed at the specified speed for earliest interception of the opponent.

ACTION: Prints one of three messages:

- 1) IF YOU TRAVEL AT nn KNOTS, INTERCEPTION IN mmm MINUTES  
AT tttttt CRSE = ppp.
- 2) NO POSSIBLE INTERCEPTION AT THIS SPEED.
- 3) IF YOU TRAVEL AT nn KNOTS, INTERCEPTION TIME EXCEEDS 3 HOURS.

Figure D.6 INTERCEPTION FUNCTION



USAGE: INTER/ESTO item description/speed of interception

IDENTIFICATION: OPINT, Opponent's Interception Course - A player function

PURPOSE: To estimate the interception course a pursuing opponent may follow.

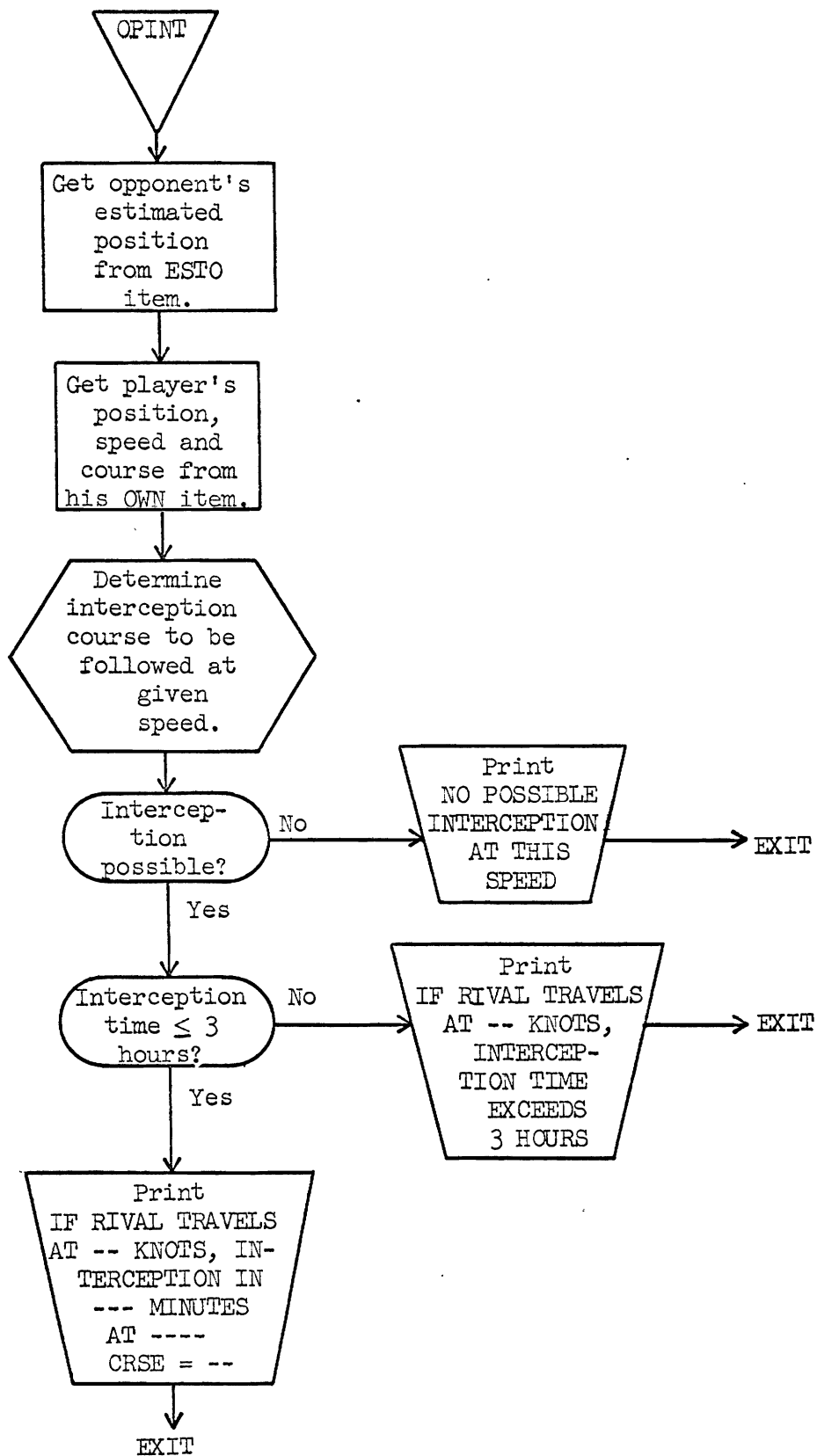
USAGE: OPINT/ESTO item description/speed of interceptor

METHOD: OPINT gets an estimate of the opponent's position from the designated ESTO item and gets the requesting player's position, speed and course from his OWN item, then calculates the course the opponent would follow at the specified speed for earliest interception.

ACTION: Prints one of three messages:

- 1) IF RIVAL TRAVELS AT nn KNOTS, INTERCEPTION IN mmm MINUTES AT  
      tttttt CRSE = ppp.
- 2) NO POSSIBLE INTERCEPTION AT THIS SPEED.
- 3) IF RIVAL TRAVELS AT nn KNOTS, INTERCEPTION TIME EXCEEDS 3 HOURS.

Figure D.7 OPPONENT RANGE FUNCTION



USAGE: OPINT/ESTO item description/speed of interceptor.

IDENTIFICATION: INTCL, Initialize Clock

PURPOSE: To initialize the game's clock and set the time scale of the game.

USAGE: INTCL/time/scale

scale may be omitted if real world time is desired.

ACTION: INTCL creates an item which contains the initial time and the time scale of the game. The player functions use these values in conjunction with the computer's built-in clock to evaluate time in the game.

RESTRICTION: Mandatory for each duel.

Note: If scale = 1, a duel is played in real-world time.

If scale < 1, a duel is played in "slow" time.

If scale > 1, a duel is played in "fast" time.

IDENTIFICATION: INTLZ, Initialize the Game

PURPOSE: To initialize the game.

USAGE: INTLZ

ACTION: INTLZ creates and stores the two players' OWN items.

RESTRICTION: Mandatory for each duel.

IDENTIFICATION: START, Start the Game

PURPOSE: To place the two vessels in their initial positions.

USAGE: START/PL<sub>1</sub>/LAT<sub>1</sub>/LO<sub>1</sub>/PL<sub>2</sub>/LAT<sub>2</sub>/LO<sub>2</sub>

where

PL<sub>i</sub> - Player's name

LAT<sub>i</sub> - Initial latitude

LO<sub>i</sub> - Initial longitude

ACTION: START inserts the specified positions and the present in the respective OWN items.

RESTRICTION: 1) Mandatory for each duel.

2) Must be executed after INTCL and INTLZ

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13. ABSTRACT  The work reported herein concerns a game whereby two competing players are given aid interactively by a large scale computer. A naval war game is used as the vehicle in this research, the primary objective of which is to develop an understanding and a methodology using on-line computers. By using the game's environment, experiments with methods for interactive and real-time communications between user and computer in complex Problem Solving are demonstrated and analyzed. It is recommended that the Navy take note of this new methodology which could have potentially great influence on the development of tactics, the training of officers and the development of integrated control systems for naval vessels.  This research demonstrates how a user defines information modules, manipulates them and selectively uses them as building blocks first for larger modules and ultimately for the solution of a problem. The computer is used as a repository for all data accrued in the game; this accumulated information is always available to a player. Because the game uses an on-line computer system to simulate the real life environment, the players can request computer computations at any time and expect responses almost immediately.			