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VESSEL SAFETY MODEL

VOLUME II
USERS' MANUAL

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FINAL REPORT

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16. Abstract

A computer model which mathematically simulates the ship's movement in defined waterways is described. Volume I presents the capabilities and usefulness for ship traffic lane selection, alternate route selection, and safety analysis. The analytic development of the equations of motion and the collision and grounding probability analysis used in the computer program are also presented. Volume II of the report consists of a complete Users' Manual. Volume III is a self-contained Programmers' Manual.

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PREFACE

Volume II presents a User's Manual, which is based on the analytic development in Volume I for the mathematical simulation of ship movement in defined waterways. This manual provides an overall description of the model, and includes the five-command structure and the predefined track input, which form the basis for all possible ship movement in the model. The overall description of ship movement in the model, together with sections on program definitions of harbors, ships, contour data, time measurements, and probabilities of collision or grounding provide the user with an adequate understanding of the mathematical model and its operation.

As for Volume I, the authors are happy to acknowledge the extensive and substantial effort of Mr. Leon Tritter in the preparation of this document.

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1. MODEL OVERVIEW

The vessel safety model provides simulated movement of ships through a defined waterway, and also furnishes information on the probabilities of collision and grounding. The ships are moved through the waterway in accordance with programmed ship motion equations, and the probabilities are printed out according to derived equations for the respective probabilities. The model is capable of a further printed output which indicates the closest point of approach (CPA) between any pair of ships in the waterway.

Supplementary information is available in Section 3 of Volume I with respect to input data requirements, the background and development of the vessel safety model, the programs and subprograms associated with the model, and a flow chart which shows the interrelationship among the programs, subprograms, and functions in the model operation.

2. HARBOR MODEL

2.1 GENERAL DESCRIPTION

a. The model will move ships in a defined harbor area according to ship movement instructions specified by the user. The motion may be anything from exact to completely random motion. The position of the ships, their velocity, heading, maneuver, and probabilities of collision and grounding are printed at specified time intervals during the run. The time intervals may vary during the run; e.g., the first hour may have print-out every minute, the second hour every second, the next ten minutes every half-second, and so on.

b. The motion of the ships is determined by ship command inputs provided by the user. The commands available and their assigned command numbers are:

(1) Straight ahead

(2) Accelerate

(3) Decelerate

(4) Left turn

(5) Right turn.

c. The paths of the ships may, alternatively, be determined by inputs specifying their track to be followed. A track consists of line segments having velocity, heading, and length. When track inputs are applied, they are converted to a sequence of the above five commands by the model.

d. The coordinate system used in the output is indicated in Figure 2-1. The heading is measured in degrees from North 0° to 360°. The x- and y- coordinates are in meters. The velocity of the ship is given in knots.

e. The command inputs are varied by a maximum amount specified by the user. These values are given in percent, and may vary from 0 to any value, allowing exact to random motion.

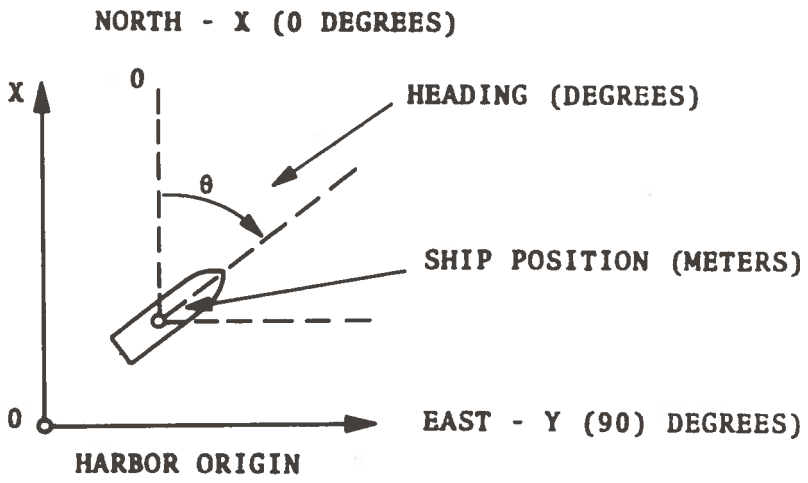


Figure 2-1. Output Coordinate System

f. Probabilities of collision and grounding are computed at the option of the user. The probabilities are cumulative for each ship throughout the time the ship is in the harbor. A ship is considered in the harbor between its start and end time, and if it has not been deleted. If, at any time step, no ship is in the harbor, the run will end.

g. Multiple runs are allowed for use in Monte Carlo type simulations. Each run will have the ship positions randomized automatically by the amount specified by the user. Maximum percentage deviations are specified.

h. A closest point of approach (CPA) calculation is performed. The CPA is the minimum distance between two ships. The calculation is performed on all pairs of ships. These distances are counted, and a frequency plot is generated at the end of the run.

i. An output tape containing the ships' positions may be generated for future reference. An example of the use of this tape is given under the description of the program PLOTS.

j. Two programs are used in generation of data required by the main program:

(1) Program LINES - to generate the harbor depth contours required by the model.

(2) Program CHAR - to generate ships' characteristics required by the motion equations.

k. The main program, as listed in Volume III, allows a maximum of:

(1) 15 ships

(2) 20 characters in the ship's name

(3) 10 different time steps per run

(4) 100 intervals in the CPA frequency plot

(5) 25 ship commands per ship

(6) 150 lines in each depth contour

(7) 5 islands per contour.

None of the above should be exceeded. These maximums are easily changed, if desired, but they should allow for varying computer capacities (i.e., an increase or decrease in the above quantities requires larger or smaller computer storage). They also provide a reasonable limitation to the core required. The model with the above maximums requires, not including system and library routines, approximately 15,000 locations. The system and library routines vary from machine to machine, and the total core required would be upward of 20,000 locations.

Note: TSC has used as many as 100 ships in a number of runs with a CDC (Computer Data Control) Model 6600. These runs were made to check out modification requirements with use of a different computer and an increased number of ships. Modification requirements to program the increase in ships were relatively easy, so that a programmer could be expected to accomplish them with little effort.

2.2 DEFINING THE HARBOR-PROGRAM LINES

2.2.1 Harbor Data Transfer

a. A harbor is defined as any waterway area. (The harbor is treated as a flat surface by the model. This is considered adequate for harbors with nominal area.) The harbor data are generated independently of the model by the program LINES, the output cards of which are provided as inputs to the model. The harbor data consist of:

(1) Coordinate points at the intersections of lines which bound the harbor and determine the harbor contour.

(2) Islands within the contour, with their coordinate points similarly determined by the intersections of lines bounding the islands.

b. The input data are obtained from a hydrographic chart, which contains the depth contours for a specific waterway represented on the chart. (The chart used for San Francisco Harbor, for which data are provided in Table 5-1 of Section 5, is divided into two parts, obtainable as C and GS chart numbers 5532 and 5533 from United States Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Washington, D.C.)

c. The following information on data transfer for a sample harbor is based on use of the hydrographic chart referred to in b. above and Figure 2-2. The coordinates for contour points picked off from the hydrographic chart are ascertained in two ways:

(1) A point is chosen at the intersection of convenient vertical and horizontal lines on the hydrographic chart (identified as longitude and latitude lines respectively) to serve as the center of coordinates for the x- and y-points of the harbor contours and associated islands.

(2) Another convenient point within the contour (such as a harbor master station) is chosen to serve as the harbor

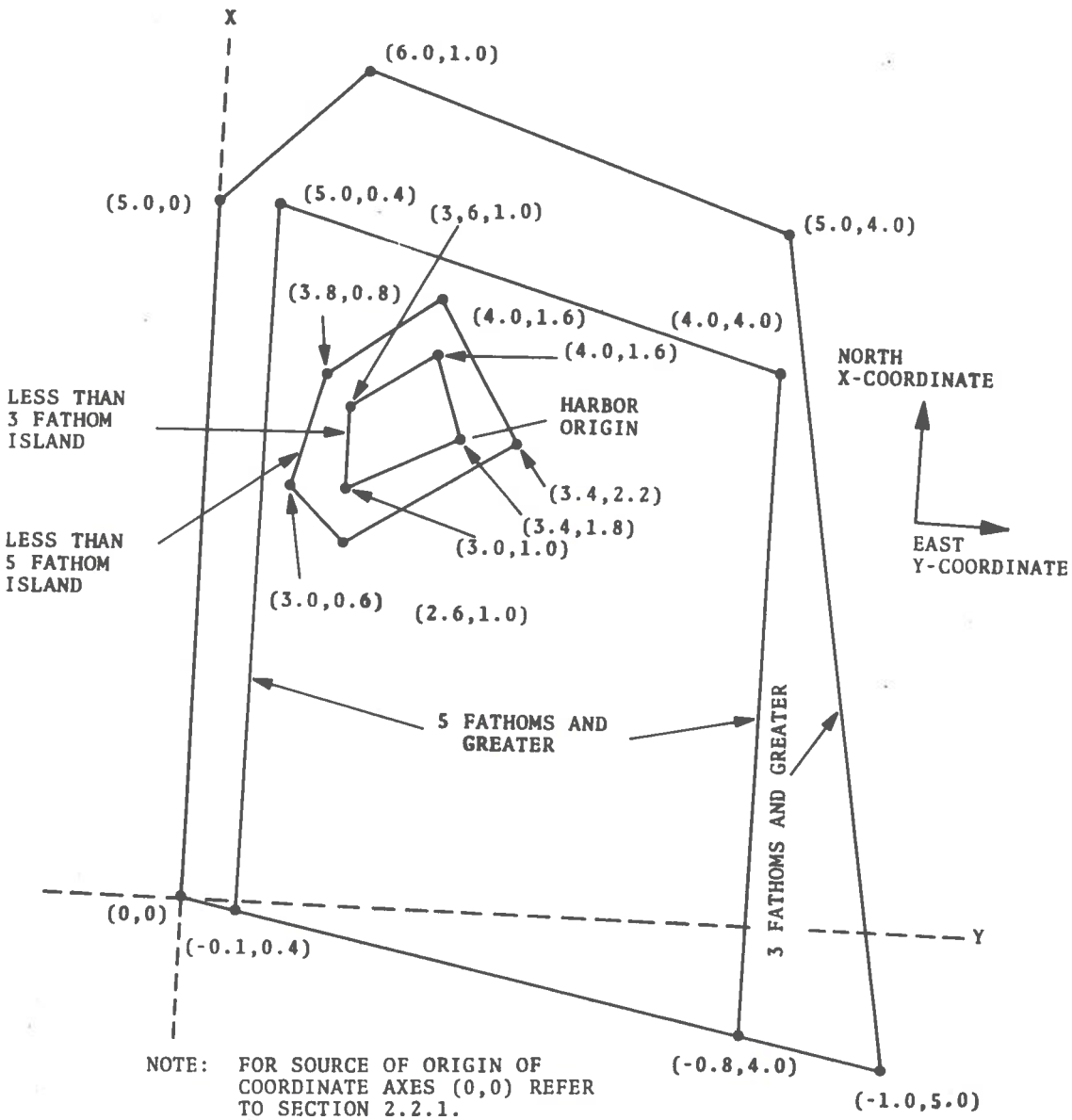


Figure 2-2. Sample Harbor

origin. In Figure 2-2 this point is indicated with coordinates (3.4, 1.8) with respect to the center of coordinates (0,0) transferred from the hydrographic chart.

d. For the purpose of setting up the harbor contours with associated islands and inserting the data into program LINES, all coordinates of the contours and islands are assigned scaled distances in inches from the longitude and latitude lines passing through the center of coordinates on the hydrographic chart. (The sample harbor of Figure 2-2 has coordinates of contours and islands marked off from the center of coordinates of the hydrographic chart with a scale of one inch to represent 5000 feet.)

e. For insertion into the model, the harbor origin is reassigned the coordinates (0,0), and is considered as the center of coordinates for data entered into the computer. Thus, all other input data coordinates from the hydrographic chart are converted to x- and y- distances (in feet) from the (0,0) coordinates of the harbor origin. The outputs from the model resulting from calculations involving inputs in feet are expressed in meters.

2.2.2 Program LINES

a. Depth contours, when taken directly from a chart, are most conveniently measured in inches from a convenient origin. The LINES program converts the depth coordinates to feet with respect to the harbor origin as required by the model. Sines, cosines, and slopes also required by the model are computed. The format of the output cards is directly acceptable to the model, and may be inserted into the data deck.

b. Once the contours are drawn with the islands (see Figure 2-2), the coordinates of the line segments are applied as inputs to LINES. Each set of coordinate inputs must be applied clockwise around the contour or island. The first and last point must coincide. The contour, measured in fathoms, is the minimum depth inside the contour (or outside its islands). The maximums allowed by the model (based on core capacity) are:

(1) Five different depth contours

(2) Five islands per contour

(3) Total number of points for a contour and its islands not to exceed 150.

Figure 2-2 shows a sample harbor with two contours, each having one island. The coordinates are measured in inches, and the scale is 1 inch = 5000 feet. The harbor origin is given the coordinates (3.4, 1.8). The coordinates printed by the main program are relative to this point.

c. A sample input to program LINES is indicated in Table 2-1. The information contained in cards 1 through 13 is described in the following text, and is also formatted in Table 2-1 according to the description in Paragraph d. Measurements of contour coordinates made during mapping of the contours and islands are with respect to a convenient center of coordinates reference (0,0) on the hydrographic chart. On this basis, the harbor origin was given coordinates (3.4, 1.8). When the main program is provided inputs, the harbor origin is considered to have (0,0) coordinates, and the remaining inputs are converted to conform to the redesignation of the harbor origin as the zero reference.

d. The information contained in the program LINES input cards is outlined below:

Card No. 1

(1) The number of contours - An integer (no decimal point) ending in column 5

(2) The X-coordinate of the harbor origin - A real number (decimal must be included) placed anywhere in columns 6-20

(3) The Y-coordinate of the harbor orgin - A real number placed anywhere in columns 21 - 35

(4) The scale factor for conversion to feet - A real number in columns 36-50

TABLE 2-1. SAMPLE INPUT TO PROGRAM LINES

FORTRAN CODING FORM

AUTHOR	PROGRAM NAME	PROGRAM NUMBER	DATE	PAGE OF

C | STATEMENT NO. | CONT | FORTRAN STATEMENT → INPUT TO PROGRAM LINES | IDENTIFICATION

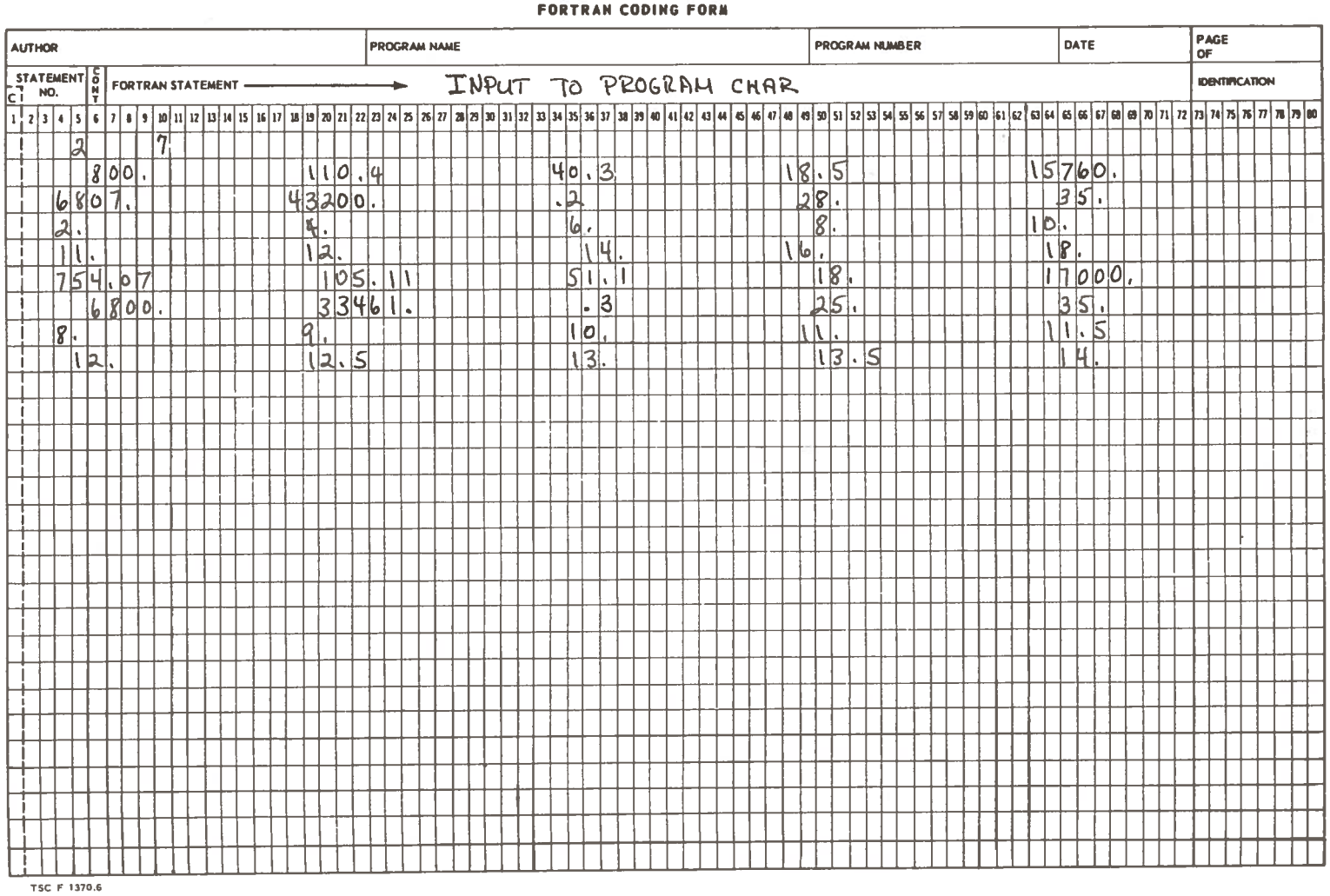
C	STATEMENT NO.	CONT	FORTRAN STATEMENT → INPUT TO PROGRAM LINES	IDENTIFICATION
	2		3.4 1.8 5000. 7	
	3		1	
	6		5	
	0.		0. 5. 0. 6. 1. 5.	4.
	-1.		5. 0. 0.	
	3.6		1. 4. 1.6 3.4 1.8 3.0	1.
	3.6		1.	
	5		1	
	5		6	
	-.1		.4 5. .4 4. 4. -.8	4.
	-.1		.4	
	3.		.6 3.8 .8 4.4 1.6 3.4	2.2
	2.6		1. 3. .6	

TSC F 1370.6

TABLE 2-2. OUTPUT DATA FROM PROGRAM LINES

```
     2
     3    1
     6    5
-0.17000000E+05-0.90000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.80000000E+04-0.90000000E+04 0.10000000E+01-0.70710675E+00 0.70710680E+00
 0.13000000E+05-0.40000000E+04-0.30000000E+01-0.94868331E+00-0.31622772E+00
 0.80000000E+04 0.11000000E+05-0.16666667E+00-0.16439906E+00-0.98639391E+00
-0.22000000E+05 0.16000000E+05-0.49999998E+01 0.98058069E+00 0.19611611E+00
-0.17000000E+05-0.90000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.99999994E+03-0.40000000E+04 0.15000000E+01-0.83205028E+00 0.55470022E+00
 0.30000000E+04-0.10000000E+04-0.33333334E+00-0.31622781E+00-0.94868328E+00
 0.00000000E+00 0.00000000E+00 0.20000000E+01 0.89442717E+00-0.44721363E+00
-0.20000000E+04-0.40000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.99999994E+03-0.40000000E+04 0.15000000E+01-0.83205028E+00 0.55470022E+00
     5    1
     5    6
-0.17500000E+05-0.70000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.80000000E+04-0.70000000E+04-0.36000000E+01-0.96351793E+00-0.26764381E+00
 0.30000000E+04 0.11000000E+05-0.99999999E-15 0.00000000E+00-0.10000000E+01
-0.21000000E+05 0.11000000E+05-0.51428572E+01 0.98161539E+00 0.19086962E+00
-0.17500000E+05-0.70000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
-0.20000000E+04-0.60000000E+04 0.25000000E+00-0.24253559E+00 0.97014251E+00
 0.20000000E+04-0.50000000E+04 0.13333334E+01-0.80000000E+00 0.60000001E+00
 0.49999999E+04-0.10000000E+04-0.60000001E+00-0.51449579E+00-0.85749289E+00
 0.00000000E+00 0.20000000E+04 0.15000000E+01 0.83205026E+00-0.55470023E+00
-0.40000001E+04-0.40000000E+04-0.99999999E+00 0.70710680E+00 0.70710677E+00
-0.20000000E+04-0.60000000E+04 0.25000000E+00-0.24253559E+00 0.97014251E+00
```

TABLE 2-3. SAMPLE INPUT TO PROGRAM CHAR



(5) The logical unit number for the system punch - An integer ending in column 55.

For each contour specified in card No. 1, the following data are required in succeeding cards:

Card No. 2

(1) The depth value in fathoms - An integer ending in column 5

(2) The number of islands for this contour - An integer ending in column 10.

Card No. 3

The number of points in the main contour and each island - Integers ending in columns 5, 10, 15, 20, etc., depending on the number of islands.

Card No. 4

Card No. 4 begins the coordinate data for the first contour. Each card contains four points (X and Y) until the end of the contour is reached. Columns 1 through 15 contain the first X, columns 16 through 30 the corresponding Y, columns 31 through 45 the second X, and so on. The islands for each contour follow the contour data and have the same format. Each island must start on a new card. In the example, the first island is started by card No. 6. The above is repeated from card No. 2 until all the contours and islands are finished.

e. The printout data of Table 2-2 represent the program LINES output based on the inputs described in Paragraph d. These outputs are provided on cards to be used as inputs for the main program.

2.3 DEFINING THE SHIPS-PROGRAM CHAR

2.3.1 Ship Characteristics

A ship possesses a group of features referred to as ship

characteristics. These characteristics are unique to each ship, and must be known before the ship's maneuverability, operational efficiency, and capability for safe travel can be analyzed. For each ship used in the vessel safety model, the following characteristics must be determined:

(1) Ship's length (between perpendiculars) (feet)

(2) Ship's beam (maximum) (feet)

(3) Mean draft (feet) (perpendicular from center of ship)

(4) Maximum velocity (knots)

(5) Ahead horsepower

(6) Astern horsepower

(7) Displacement (tons)

(8) Windsail characteristics (dimensionless ratio)

(9) Reverse time (seconds) to reverse engine in deceleration process

(10) Maximum rudder angle (degrees)

(11) Turning velocities (10) to be used in computing a quadratic fit to the equation relating turning velocity to initial velocity.

2.3.2 Program CHAR

a. Program CHAR is an independent program which is run to prepare input cards for the main program.

b. The program inputs the ship characteristics, and computes the data required by the main program. For each ship 20 constants are generated. The card outputs are in a form acceptable to the main program. An example is given in Table 2-3 of two sets of characteristics. The following text indicates the manner in which the input cards are set up.

Card No. 1

(1) The number of sets of characterisitcs - An integer

ending in column 5.

(2) The logical unit number for the system punch - An integer ending in column 10.

Card No. 2

The first 5 characteristics in real number format (decimal point must be included) in columns 1-15, 16-30, 31-45, 46-60, 61-75 respectively. Each number may appear anywhere in its field.

Card No. 3

The characteristics 6 through 10 in the same format as card No. 2.

Cards No. 4 and 5

The ten turning velocities (knots, unlimited range),five per card, in the same format as above.

The sequence from card No. 2 is repeated for each set of characteristics. For each set, four cards provide outputs, and must be placed following the ship's name in the main program input data deck. Table 2-4 provides the output data referred to above for the program CHAR inputs of Table 2-3.

TABLE 2-4. OUTPUT DATA FROM PROGRAM CHAR

0.8000000E+03	0.1104000E+03	0.4030000E+02	0.1050000E+02	0.1576000E+05
0.6807000E+04	0.4320000E+05	0.2000000E+00	0.2000000E+02	0.2163903E+06
0.1424764E+05	0.3699762E-02	0.6082567E-01	0.1536272E+02	0.3158126E+07
0.2958737E+03	0.6392429E+05	0.1994616E+00	-0.8658371E-01	0.7388185E-02
0.7540700E+03	0.1051100E+03	0.5110000E+02	0.1000000E+02	0.1700000E+05
0.6800000E+04	0.3346100E+05	0.3000000E+00	0.2500000E+02	0.2398997E+06
0.9423403E+04	0.4219993E-02	0.6496147E-01	0.1073325E+02	0.2446159E+07
0.3536257E+03	0.6051562E+05	0.2138730E+00	-0.1024249E+00	0.8048574E-02

3. MAIN PROGRAM - DATA INPUT

3.1 GENERAL

Preparation of a run of the main program involves a number of considerations, of which the following are typical:

a. It is necessary for tracks to be laid out.

b. Initial conditions, time-step intervals, and probability options must be defined.

c. Error conditions must be set.

This information is provided in order to make useful and meaningful runs. By such information conditions are set up which are adequate and sufficient to provide the necessary outputs for given input conditions. For example, duplicating a known maritime collision would require the use of the ships involved only, with time-step intervals to suit the density of waterway traffic. No probabilities are needed. Time-steps may vary from large steps in the portion of the track away from the vicinity of the collision to small steps near points where the collision occurred. It is also possible that the probability of collision between a ship and any one of other adjacent ships may be investigated, given conditions with respect to weather, ship densities, tide and wind effect, ship velocities, headings, human factors, and navigational aids. This problem is more complex than the preceding one; however, the inclusion of the above conditions will provide the necessary information from which probability determinations can be made.

3.2 DATA INPUTS

The main program receives inputs of the type already discussed in Section 3.1 and treated in greater detail in Sections 3.2.1 through 3.2.5. The different categories of inputs are shown in Figure 3-1, in which the indicated blocks represent groups of cards with the data and command information to be processed.

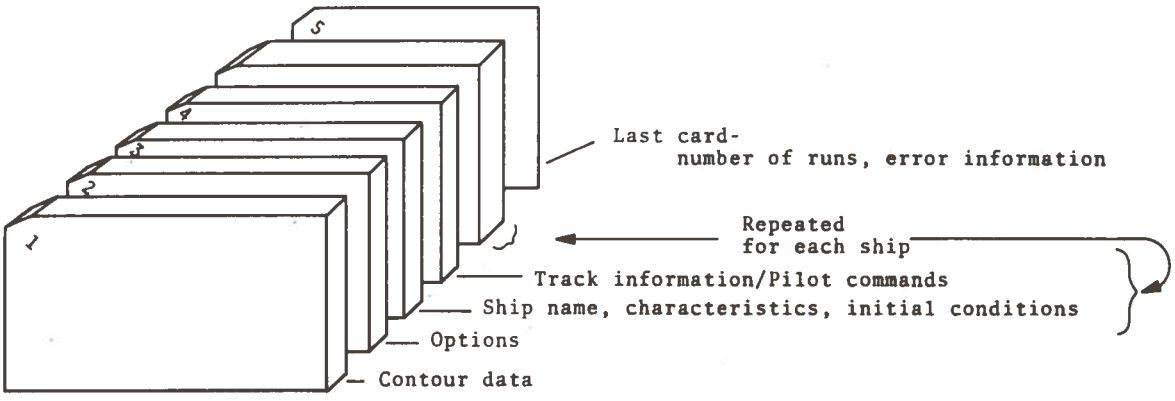


Figure 3-1. Data Deck Setup for Main Program

3.2.1 Contour Data

The contour data are taken directly as output from the program LINES.

3.2.2 Options

The set of cards comprising the options group includes input information arbitrarily selected by the user to conform with the given requirements of a particular problem. The information is inserted on cards according to the format described below.

Card No. 1

a. Total number of ships - an integer ending in column 5.
b. Number of different time increments to be used during execution - an integer ending in column 10.

c. Option for generating tape file containing ship's position - an integer in column 15.

(1) If equal to 1, a tape is generated.
(2) If not, no tape is generated.

d. Option for action to be taken if probability of collision and/or probability of grounding becomes greater than a specified amount - an integer in column 20.

(1) If equal to 1, take no action.
(2) If equal to 2, stop ship or ships involved.
(3) If equal to 3, delete ship or ships involved.

e. Probabilities to be calculated - an integer in column 25.

(1) If equal to 1, no probabilities are calculated.
(2) If equal to 2, only probability of collision is calculated.
(3) If equal to 3, only probability of grounding is calculated.
(4) If equal to 4, both probabilities (collision and grounding) are calculated.

f. Maximum value used with option in d. - real number (decimal point must be included) between 0 and 1 located anywhere in columns 26 to 40.

g. Maximum distance (meters) ships will be checked for closest point of approach. (This is the maximum value on the frequency distribution.) Real number is located anywhere in columns 41 to 55.

h. Option for printing distances - an integer in column 60.

(1) If equal to 1, print only distances between ships that are less than the value specified in g.

(2) If not equal to 1, print all distances between ships. (When a large number of ships is being used, this option should be set equal to 1 to avoid large printout of all distances between all pairs of ships.)

i. Number of intervals to be used in frequency plot of CPA's (closest points of approach) - an integer ending in column 65. (A value of 50 will produce one printer page.)

Card No. 2 to End of Options Group

Each card of this group contains an end time, a time increment and the print frequency to be used for this time increment. Each card contains one value of each of the above. There will be, therefore, the same number of cards as the number specified in b. The first value of each card is the time in seconds of the end of that interval, and is located in columns 1 through 15 in real format. The time-step to be used in seconds is located in columns 16 through 30 in real format. The print frequency is an integer ending in column 35. If the print frequency is 5, for example, the ship's position (and other parameters of the printout) will be printed every fifth time-step.

3.2.3 Ship Name, Characteristics, and Initial Conditions

The distinguishing data for each ship must include its name, its characteristics, and the initial conditions under which it will function during a model run. The input data for a particular ship are entered into the computer in accordance with the following card format.

Card No. 1

Ship's name - may contain alphabetic or numeric data in columns 1 through 20.

Cards No. 2 through 5

Ship's characteristics and constants - obtained from outputs of program CHAR.

Card No. 6

Human factor and on-board navigational capability. The human factor is a variable quantity which is related to the standard deviation (σ) terms in the probability of collision calculations of Appendix C, Volume I of this document. The human factor contributes to the determination of the x- and y-components of the standard deviation (σ_x and σ_y). It is given as the ratio of an average crew's ability to the ability of the present crew, and

is applied as an input to the main program. The on-board navigational capability, which is also used with reference to the standard deviation, is the error (in meters) of position due to on-board equipment. The total on-board capability is the product of the human factor and the on-board capability. The human factor is in real format, and is located in columns 1 through 15. The on-board capability is in real format, and is located in columns 16 through 30.

Note: Additional information on human factors and on-board navigational capability is available in Section 6 of Volume I of this document.

Card No. 7

This card is the last of the group. It contains the start time, the end time, and the starting position (in meters) of the ship. The times are in seconds, and relative to a harbor time of zero. At least one ship must start at time zero. Columns 1 through 15 contain the start time in seconds; columns 16 through 30 contain the end time in seconds; columns 31 through 45 contain the initial x-coordinate in meters; and columns 46 through 60 contain the initial y-coordinate in meters.

3.2.4 Path of Ship

The ship's path can be programmed in terms of either of two modes:

3.2.4.1 Track Information

3.2.4.2 Pilot Commands

Selection of either mode and the number of cards with their appropriate formats are discussed below.

Card No. 1 for Path of Ship

Selects code of input.

(1) If column 5 contains a 1, track information input is selected.

(2) If column 5 contains a 2, pilot command input is selected.

Once the mode is selected, the card routine for the respective modes is sequenced as follows:

3.2.4.3 Track Information Mode - The ship's track is broken into straight line segements, each containing a velocity, a heading, and a length. The first card of track information contains an integer which ends in column 5 and signifies the number of line segments. The following cards contain for each segment (one card per segment) the heading (degrees from North clockwise) in columns 1 through 15, the velocity for this segment (in knots) in columns 16 through 30, and the length of the segment (in meters) in columns 31 through 45 (each in real format).

3.2.4.4 Pilot Command Mode - Pilot commands are applied as input according to the command mode and value of the command. The following card routine indicates the procedure:

Card No. 1

(1) Starting velocity (knots) - real number, columns 16 through 30.

(2) Starting heading (degrees) - real number, columns 1 through 15.

Card No. 2

Number of commands to be read - an integer ending in column 5.

Card No. 3 to End of Pilot Command Group

These cards contain the mode of the command and its value. Each card contains one command. The mode is in column 1 and is an integer, and the value is a real number in columns 2 through 16. The commands have the following meaning and units:

Mode	Meaning and Units
1	Straight ahead for value meters
2	Accelerate to a speed of value knots
3	Decelerate to a speed of value knots
4	Turn left value degrees
5	Turn right value degrees.

3.2.5 Continuation of Data Deck Setup

On completion of the input for the path-of-ship data, the procedures described in Sections 3.2.3 and 3.2.4 are repeated for each ship until all the ships are defined. The final card of the data deck is then inserted to provide information on the number of runs to be made and the maximum variation to be used in randomizing the input. (The specifications given here are related to the Monte Carlo operation, an automatic operation which involves a number of runs and super-position of random plus-or-minus errors on the given commands up to a permissible limit within the number of runs executed. The computer repeats each run with different random errors for as many runs as have been specified.) The format used for the final card is as follows:

Final Card of Data Deck

a. Number of runs - an integer ending in column 5.
b. Maximum percent change in initial position (the initial position used during execution is the one given with an error of plus or minus this percent) - real number, columns 6 through 15.
c. Maximum percent change in velocities - real number, columns 16 through 25.
d. Maximum percent change in headings - real number, columns 26 through 35.
e. Maximum percent change in straight paths (mode 1 commands)- real number, columns 36 through 45.
f. Maximum percent change in navigational error - real number, columns 46 through 55.

g. Random integer needed to start randomizing data in the model - an integer ending in column 65, columns 56 through 65.

4. PLOTTING THE SHIP'S TRACKS

4.1 PROGRAM PLOT

a. The program PLOT uses the data tape generated by the main program to plot ship's tracks or the frequency curve given by the printer plot (Figure 4-1 and Table 4-1). The tape is on logical unit 9.

b. The equipment used in performance of the program is assumed to be a Calcomp plotter. (Because of similarity among other plotters to the Calcomp plotter, a number of plotters will be suitable for this application with relatively minor changes. The capabilities of the Calcomp plotter are demonstrated further in Section 5 of Volume I of this document.)

c. Figure 4-1 shows a sample plot of the paths taken by two ships in a waterway on the basis of the program PLOT input data of Table 4-1. The bounded figure represents an island, whose contour data are taken directly from the main program data deck. One of the bounding points of the island, marked X, the harbor origin, serves as reference for the remaining plot data. The plots of the ships' travel are identified by characters such as A and B for each time-step in the range determined by the input data. The characters are plotted so they can be read (i.e., right side up) in the direction of ship travel. This is borne out in Figure 4-1 by the positions of characters A and B with respect to the direction of ships A and B, as indicated by the respective arrows.

4.2 CARD DECK INPUT FOR PROGRAM PLOT

The card data which serve as program input for the print output of Figure 4-1 are described as to content and card format in the following listing:

Card No. 1

Run number (normally 1) - An integer ending in column 5.

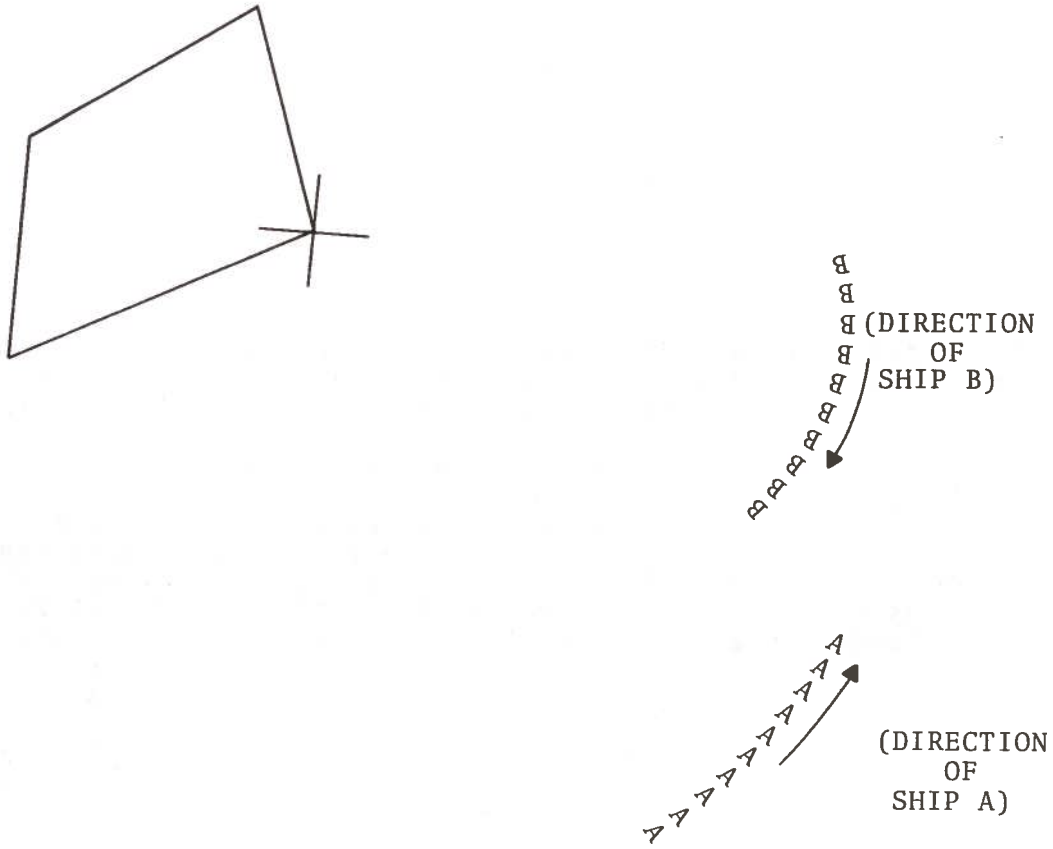


Figure 4-1. Sample Plot of Ships in Waterway

TABLE 4-1. INPUT DATA FOR SAMPLE PLOT OF SHIPS IN WATERWAY

```
1
2
1    2
A    B
 0.          200.
3    1
6    5
-0.17000000E+05-0.90000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.80000000E+04-0.90000000E+04 0.10000000E+01-0.70710675E+00 0.70710680E+00
 0.13000000E+05-0.40000000E+04-0.30000000E+01-0.94868331E+00-0.31622772E+00
 0.80000000E+04 0.11000000E+05-0.16666667E+00-0.16439906E+00-0.98639391E+00
-0.22000000E+05 0.16000000E+05-0.49999998E+01 0.98058069E+00 0.19611611E+00
-0.17000000E+05-0.90000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.99999994E+03-0.40000000E+04 0.15000000E+01-0.83205028E+00 0.55470022E+00
 0.30000000E+04-0.10000000E+04-0.33333334E+00-0.31622781E+00-0.94868328E+00
 0.00000000E+00 0.00000000E+00 0.20000000E+01 0.89442717E+00-0.44721363E+00
-0.20000000E+04-0.40000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.99999994E+03-0.40000000E+04 0.15000000E+01-0.83205028E+00 0.55470022E+00
```

Card No. 2

Number of ships to be plotted - An integer ending in column 5.

(1) If equal to zero, a frequency plot is generated, and no more data are required.

(2) If not, Card No. 3 is used.

Card No. 3

Ship numbers to be plotted - integers ending in columns 5, 10, and so on until all the ships to be plotted are named.

Card No. 4

Identifying symbols to be used on the plot - a character or number in columns 5, 10, 15, and so on until a character is specified for each ship to be plotted.

Card No. 5

Start and end times (in seconds) for the plot. The start time is a real number, located in columns 1 through 15. The end time is a real number, located in columns 16 through 30.

Card No. 6 to End of Card Deck

The remaining cards contain contour data for one contour and its islands taken directly from the main program data deck.

5. SAN FRANCISCO CONTOUR DATA AND PLOT OF ZERO FATHOM CONTOUR

An outline of the San Francisco Harbor is shown in Figure 5-1. This outline was obtained from data of coordinates in Table 5-1. The data used to form the harbor outline are based on a convenient center of x-y coordinates (0,0) chosen on a hydrographic chart of the entrance to San Francisco Bay. (This chart is discussed in detail in Section 2.2.1.) The orientation of the x- and y-axes of the chart is indicated on Figure 5-1, and is made to correspond with that shown in Figure A.1-1 of Appendix A, Volume I of this document.

Note: The printed matter included in Figure 5-1 is not part of the plot of the harbor. Locations within the San Francisco Bay are identified (supplementary to the plot outline) to enable the reader to correlate the layout of Figure 5-1 with the corresponding locations on the San Francisco Bay area hydrographic chart (C and G.S. No. 5532).

The x- and y-distances are measured from a center of coordinates (0,0) intersection of the vertical axis (122°30' longitude on the hydrographic chart) with the horizontal axis (37°50' latitude). All points on the contour are given in inches, with the scale of measurement given as 1 inch = 3344.8 feet. With respect to the center determined from the above, the harbor origin shown in Figure 5-1 has these x- and y-coordinates:

x = -2.55 inches
y = 11.78 inches.

TABLE 5-1. SAN FRANCISCO HARBOR CONTOUR DATA

4							
5							
95							
-14.5	-5.	.7	-5.	-.75	-2.95	-1.	-3.2
-2.	-2.3	-.85	-1.87	-1.45	.15	.3	2.6
1.6	2.	2.7	2.1	5.6	-1.3	4.8	.4
6.3	.15	6.5	.05	6.2	1.65	4.4	2.5
3.2	3.7	3.5	3.7	5.25	5.45	6.65	4.5
6.6	3.7	7.8	2.45	11.05	1.0	13.6	1.0
16.7	4.65	19.75	1.0	20.25	3.0	20.75	3.0
20.75	2.2	20.5	1.9	30.4	-.5	30.2	3.25
28.4	5.0	32.5	0.3	34.0	8.5	34.0	8.7
32.55	0.0	20.45	16.4	25.3	18.5	25.85	21.7
26.45	21.85	30.2	19.35	30.3	19.7	26.1	22.25
25.4	24.0	24.7	24.0	24.2	20.6	19.7	16.15
19.7	11.75	17.2	10.4	16.8	11.0	14.7	8.0
14.55	6.17	13.25	6.3	11.2	7.25	9.66	9.82
8.25	9.7	7.75	14.1	5.7	15.8	4.55	15.27
3.3	15.85	1.6	12.0	1.5	12.05	3.5	16.7
1.3	17.4	-2.75	13.85	-3.6	14.65	-4.3	17.25
-4.3	19.0	-4.65	19.9	-5.15	21.05	-5.5	21.15
-4.55	19.3	-4.45	18.15	-4.6	17.4	-3.9	14.6
-5.55	14.7	-9.1	23.85	-10.2	20.8	-14.5	24.0
-14.5	9.4	-13.4	9.4	-13.5	10.8	-12.4	10.3
-11.95	+10.7	-13.4	12.1	-11.4	12.5	-9.5	10.6
-4.75	10.1	-2.6	8.4	-2.6	2.0	-4.8	1.1
-5.4	-1.2	-14.5	-.1	-14.5	-5.0	.	.
8							
15.1	6.9	16.25	8.0	16.25	8.55	15.6	8.55
15.25	8.0	15.2	7.4	14.95	7.15	15.1	6.9
11							
3.0	4.85	3.95	5.4	3.7	5.52	3.7	5.7
3.95	5.7	4.3	6.1	4.0	6.75	2.05	7.2
2.45	6.1	2.25	5.75	3.0	4.85		
0							
7.5	10.0	7.45	12.55	7.2	12.8	6.52	13.0
6.8	12.25	6.0	12.25	7.2	11.7	7.15	11.5
7.5	10.0						
11							
-.1	10.0	-.25	11.6	-1.35	12.2	-1.85	11.27
-2.15	11.4	-1.95	12.3	-2.8	12.0	-2.5	11.5
-1.85	11.15	-.85	10.5	-.1	10.9		
6							
-.5	6.7	-.8	7.05	-.95	6.95	-.75	6.6
-.55	6.45	-.5	6.7				
7							
80							
-8.9	-4.0	-2.7	-4.0	-2.23	-3.63	-1.82	-3.6
-1.4	-4.0	-.19	-4.0	-1.23	-3.19	-2.19	-2.6
-2.18	-2.28	-1.44	-1.97	-1.15	-.9	-1.54	.1
-.85	1.02	-.87	1.96	0.28	2.7	1.28	2.26
3.08	3.72	4.06	3.96	4.6	5.0	5.37	5.4
7.7	3.13	7.02	3.22	7.82	3.9	11.79	3.42
17.62	4.64	18.45	5.68	20.78	8.31	19.47	7.47
22.02	10.74	22.2	11.32	24.16	14.3	25.02	18.28

TABLE 5-1. SAN FRANCISCO HARBOR CONTOUR DATA (CONTINUED)

25.2	18.24	26.0	21.69	25.55	23.2	24.04	23.2
24.47	19.0	24.88	18.25	23.01	14.23	21.48	10.51
15.45	6.1	13.55	5.0	13.55	5.65	14.28	5.48
14.13	5.20	10.2	7.26	9.61	7.01	11.43	5.7
9.89	4.25	9.2	4.26	9.91	4.68	8.63	4.61
7.48	5.4	7.87	5.71	7.26	6.71	7.7	6.59
9.35	6.32	9.55	6.6	7.91	6.78	6.15	8.07
.2	9.1	-1.13	10.68	-2.49	11.15	-3.26	12.55
-8.0	14.54	-13.09	16.1	-13.65	13.8	-12.9	12.41
-11.4	12.74	-10.95	12.39	-4.65	10.13	-2.7	8.77
-2.11	7.59	-2.78	4.03	-2.09	1.89	-4.2	1.3
-4.7	-.5	-5.64	-1.53	-9.21	-1.7	-8.9	-4.0
11							
1.85	4.8	3.1	4.58	3.68	4.47	3.51	4.07
3.83	5.05	4.48	6.12	4.21	6.62	3.3	7.14
2.05	7.24	2.25	6.08	1.85	4.8		
5							
-.68	6.03	-.29	6.54	-.69	7.09	-.93	6.94
-.68	6.03						
73	6						
-.2	-3.9	-.25	-3.67	-2.1	-2.57	-2.1	-2.29
-1.16	-1.9	-1.47	.15	-.81	1.0	-.86	1.9
.2	2.68	1.6	2.07	5.4	5.5	6.9	4.6
7.5	3.15	9.78	2.35	9.38	2.8	17.78	4.9
17.32	5.1	20.05	6.02	24.24	14.07	24.0	14.18
25.05	21.78	25.44	24.4	24.62	24.45	24.66	22.0
21.35	12.51	18.22	8.00	14.4	6.1	10.57	7.0
8.14	8.78	7.77	11.61	7.0	11.9	9.2	11.72
9.82	10.98	9.02	11.02	9.18	11.95	7.45	12.26
7.06	9.02	3.57	9.65	2.31	10.19	1.29	11.91
-2.7	13.55	-2.14	14.54	-1.88	15.45	-1.13	16.23
-1.52	16.6	-1.40	16.15	-2.48	15.4	-2.33	14.48
-3.15	13.37	-4.15	14.36	-6.12	14.83	-6.24	16.96
-6.95	16.9	-7.0	16.47	-6.5	15.88	-6.48	14.9
-9.3	16.18	-8.95	15.72	-14.48	19.3	-14.48	11.62
-11.39	12.51	-8.8	10.68	-4.73	10.1	-2.17	7.82
-2.8	3.85	-2.33	2.05	-4.25	1.4	-4.74	-.68
-5.7	-1.38	-10.05	-1.26	-14.5	-.32	-14.52	-3.8
-.2	-3.9						
9							
2.2	5.0	3.07	4.69	3.6	5.29	4.39	6.14
4.1	6.68	2.08	7.28	1.95	7.05	2.2	6.84
2.2	5.0						
10							
-2.64	11.12	-.78	10.5	-.3	10.57	.09	11.1
-.05	11.6	-1.12	12.15	-1.95	12.3	-2.5	12.1
-2.85	12.38	-2.64	11.12				
10							
5.15	8.51	5.63	8.40	5.8	8.09	6.33	7.7
6.48	7.86	7.8	7.47	7.9	7.76	5.5	8.8
5.1	8.85	5.15	8.51				
5							
10.05	6.14	10.56	5.8	10.87	5.91	10.66	6.1
10.05	6.14						

TABLE 5-1. SAN FRANCISCO HARBOR CONTOUR DATA (CONTINUED)

```
5
  14.05      5.57    14.25      5.54    14.3       5.87    14.14      5.8
  14.05      5.57
5
-.69       6.33       -.31       6.55       -.74       7.03       -.91       6.92
-.69       6.33
          5
50
 -14.5      -5.0      1.45      -5.0      -2.1      -2.46      -1.05      -1.54
  -1.49       .05      -.17      2.45       1.1       2.22       3.18       3.4
   3.09      3.69      4.07       4.0       4.63       5.0       5.39       5.5
   8.71       2.6      8.24      3.68      11.55      3.34      18.25      5.38
  22.05      10.1     21.47      9.75      21.32      9.79      24.1      14.72
  26.0      21.73      25.5     23.25       25.4      24.0       24.8       24.0
  24.75      22.0     23.91     17.04      24.25     17.04      23.88      14.92
  22.06      12.0     14.38       6.0      10.69      6.83        9.6       7.87
   8.73      7.76      9.48      6.88       8.02       6.9       4.27       9.13
    .41       9.4      -2.1     11.06      -3.14     12.38      -2.98      13.08
  -3.27     13.18     -3.32     12.56       -5.0     14.38      -5.13      16.09
  -5.86     16.04     -5.39     15.85       -5.3     14.22     -14.42      16.88
 -14.42      12.8    -11.25     12.55      -2.84      8.89      -2.35        7.7
  -2.85      2.82     -2.22       1.9      -4.48      1.12      -4.67       -.57
  -5.68      -1.6     -14.5       -.4     -14.5      -5.0
11
    1.9      4.95      3.05      4.66       3.27      5.05       3.95       5.22
    4.4       6.2      3.59       7.0        2.0      7.24        1.8       6.99
    2.1       6.9      2.14      5.42        1.9      4.95
6
    8.35      5.2      10.0      5.81       9.64       6.1       8.88       6.56
    7.82      6.57      8.35       5.2
5
  14.05      5.46      14.3      5.38       14.4      5.81      14.14      5.88
  14.05      5.46
4
  16.83      4.97     17.18       5.1      16.73       5.3      16.83      4.97
7
   -.69      6.12       -.38      6.65       -.87      7.05       -1.0      6.86
   -.73      6.53       -.8       6.23       -.69      6.12
```

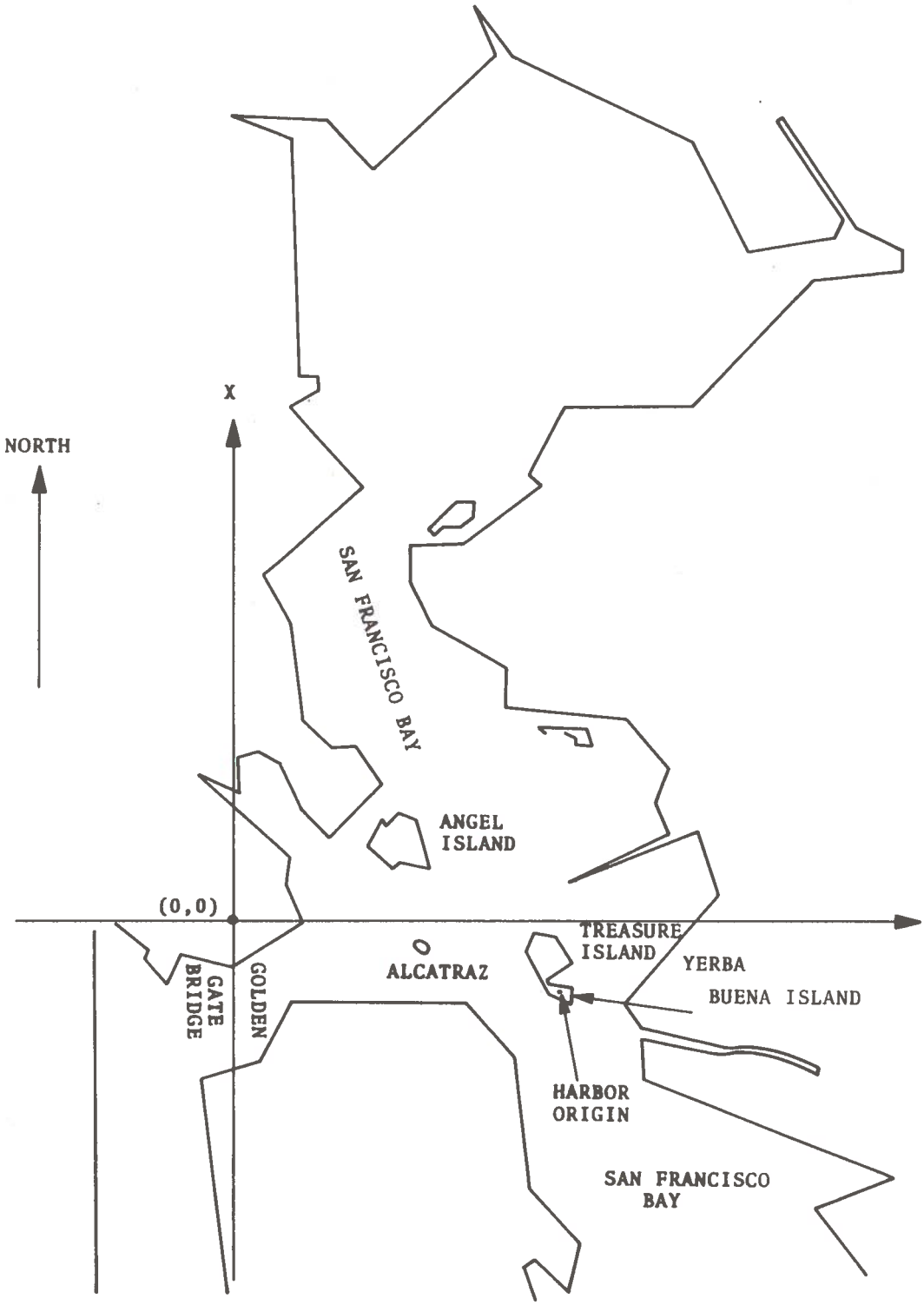


Figure 5-1. Outline of San Francisco Harbor

MAIN PROGRAM

EXECUTION EXAMPLES

(APPENDICES A,B,C)

APPENDICES - A THROUGH C

Appendices A, B, and C provide examples of use of the main program. The examples include generation of a plot tape for two ships in a waterway under different conditions of travel in the ship's path, the probability of collision, and the probability of grounding.

APPENDIX A

EXECUTION EXAMPLE 1

Example 1 shows the two modes of input for ship's paths. Ship 1 (Ore Mercury) follows defined tracks and ship 2 (S.S. Persepolis) follows pilot commands. A plot tape was generated by this run and the results of the plot are shown in Figure 4-1 of Section 4. (See Section 4.1 for a discussion of Figure 4-1.)

The frequency distribution plot at the end of the run contains the number of times ships approached each other within the distance specified by the interval. The interval is given on the left, and the number of occurrences is given next to the interval. The maximum number of occurrences is the maximum in any interval. It is also the value at the right-most dotted line. The dotted line in the center is the midpoint between 0 and the maximum number of occurrences.

The data in Table A-1 are divided into numbered groups. The group numbers localize the data to cards which form the card groups of Figure 3-1. Thus, for example, the data in Table A-1 contained in group bracket 3 are also on cards contained in the group of Figure 3-1 marked 3 (and hence related to ship's name, characteristics, and initial conditions).

TABLE A-1. INPUT DATA FOR EXAMPLE 1

```
    2
    3    1
    6    5
-0.17000000E+05-0.90000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.80000000E+04-0.90000000E+04 0.10000000E+01-0.70710675E+00 0.70710680E+00
 0.13000000E+05-0.40000000E+04-0.30000000E+01-0.94868331E+00-0.31622772E+00
 0.80000000E+04 0.11000000E+05-0.16666667E+00-0.16439906E+00-0.98639391E+00
-0.22000000E+05 0.16000000E+05-0.49999998E+01 0.98058069E+00 0.19611611E+00
-0.17000000E+05-0.90000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.99999994E+03-0.40000000E+04 0.15000000E+01-0.83205028E+00 0.55470022E+00
 0.30000000E+04-0.10000000E+04-0.33333334E+00-0.31622781E+00-0.94868328E+00
 0.00000000E+00 0.00000000E+00 0.20000000E+01 0.89442717E+00-0.44721363E+00
-0.20000000E+04-0.40000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.99999994E+03-0.40000000E+04 0.15000000E+01-0.83205028E+00 0.55470022E+00
    5    1                                                                    1
    5    6
-0.17500000E+05-0.70000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.80000000E+04-0.70000000E+04-0.36000000E+01-0.96351793E+00-0.26764381E+00
 0.30000000E+04 0.11000000E+05-0.99999999E-15 0.00000000E+00-0.10000000E+01
-0.21000000E+05 0.11000000E+05-0.51428572E+01 0.98161539E+00 0.19086962E+00
-0.17500000E+05-0.70000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
-0.20000000E+04-0.60000000E+04 0.25000000E+00-0.24253559E+00 0.97014251E+00
 0.20000000E+04-0.50000000E+04 0.13333334E+01-0.80000000E+00 0.60000001E+00
 0.49999999E+04-0.10000000E+04-0.60000001E+00-0.51449579E+00-0.85749289E+00
 0.00000000E+00 0.20000000E+04 0.15000000E+01 0.83205026E+00-0.55470023E+00
-0.40000000E+04-0.40000000E+04-0.99999999E+00 0.70710680E+00 0.70710677E+00
-0.20000000E+04-0.60000000E+04 0.25000000E+00-0.24253559E+00 0.97014251E+00
    2    1    1    2    4      .9          2000.          0   50              2
    240.           10.             1
ORE MERCURY
 0.80000000E+03  0.1104000E+03  0.4030000E+02  0.1850000E+02  0.1576000E+05
 0.68070000E+04  0.4320000E+05  0.2000000E+00  0.2800000E+02  0.2163903E+06    3
 0.1424764E+05   0.3699762E-02  0.6082567E-01  0.1536272E+02  0.3158126E+07
 0.2958737E+03   0.6392429E+05  0.1994616E+00 -0.8658371E-01  0.7388185E-02
    1.6            20.
    0.             200.           -2745.          1525.
    1                                                                        4
    2
    45.            12.            762.5
    30.            14.            915.
S. S. PERSEPOLIS
 0.75407000E+03  0.1051100E+03  0.5110000E+02  0.1800000E+02  0.1700000E+05
 0.68000000E+04  0.3346100E+05  0.3000000E+00  0.2500000E+02  0.2398997E+06    3
 0.94234000E+04  0.4219993E-02  0.6496147E-01  0.1073325E+02  0.2446159E+07
 0.3536257E+03   0.6051562E+05  0.2138730E+00 -0.1024249E+00  0.8048574E-02
    2.             45.
    0.             240.           305.          2135.
    2
    14.            180.                                                      4
    4
1    610.
5    45.
3    12.
1    200.
    1   10.      3.        1.        5.      5.          14395                5
```

TABLE A-2. PROGRAM PRINTOUT FOR EXAMPLE 1

SHIP NO.	NAME
1	ORE MERCURY
2	S. S. PERSEPOLIS

SHIP	SHIP FACTOR	NAV. CAP. (METERS)	START X (METERS)	START Y (METERS)	START HEAD. (DEGREES)	START VEL. (KNOTS)	START TIME (SECS)	END TIME (SECS)
1	1.43	20.00	-2745.00	1525.00	45.00	12.00	0.00	300.00
2	2.32	45.00	305.00	2135.00	180.00	14.00	0.00	240.00

SHIP CHARACTERISTICS

1

3.8707000E+03	0.1104000E+03	0.4030000E+02	0.1850000E+02	0.1576000E+05
2.6807000E+04	0.4320000E+05	0.2000000E+00	0.2000000E+02	0.2163983E+06
2.1424764E+05	0.3699762E-02	0.6082567E-01	0.1536272E+02	0.3158186E+07
3.2958737E+03	0.6392429E+05	0.1994616E+00	-0.8658371E-01	0.7388185E-02

2

2.7540700E+03	0.1051100E+03	0.5110000E+02	0.1800000E+02	0.1700000E+06
2.6800000E+04	0.3346100E+05	0.3000000E+00	0.2500000E+02	0.2398997E+06
8.9423403E+04	0.4219993E-02	0.6496147E-01	0.1073325E+02	0.2446189E+07
2.3536257E+03	0.6051562E+05	0.2138730E+00	-0.1024249E+00	0.8048574E-02

SHIP COMMANDS

1

STRAIGHT AHEAD FOR 537.28 METERS
TURN LEFT 15.00 DEGREES
ACCELERATE TO A SPEED OF 14.00 KNOTS
STRAIGHT AHEAD FOR 83.93 METERS

2

STRAIGHT AHEAD FOR 610.00 METERS
TURN RIGHT 45.00 DEGREES
DECELERATE TO A SPEED OF 12.00 KNOTS
STRAIGHT AHEAD FOR 200.00 METERS

TABLE A-2. PROGRAM PRINTOUT FOR EXAMPLE 1 (CONTINUED)

```
**********
*        *
* RUN NUMBER 1 *
*        *
**********
```

SHIP	SHIP NAV. CAP. (METERS)	START X (METERS)	START Y (METERS)	START HEAD. (DEGREES)	START VEL. (KNOTS)	START TIME (SECS)	END TIME (SECS)
1	32	-2485.57	1537.12	44.88	11.80	0.00	200.00
2	96	281.82	2295.63	180.76	14.04	0.00	240.00

SHIP COMMANDS

1

STRAIGHT AHEAD FOR 545.69 METERS
TURN LEFT 15.07 DEGREES
ACCELERATE TO A SPEED OF 14.32 KNOTS
STRAIGHT AHEAD FOR 86.23 METERS

2

STRAIGHT AHEAD FOR 605.97 METERS
TURN RIGHT 45.08 DEGREES
DECELERATE TO A SPEED OF 12.17 KNOTS
STRAIGHT AHEAD FOR 200.48 METERS

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	12.000	-2442.552	1579.968	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	12.000	209.542	2294.678	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 2746.710

TABLE A-2. PROGRAM PRINTOUT FOR EXAMPLE 1 (CONTINUED)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	2[illegible].000	-2399.530	1622.814	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	2[illegible].000	137.262	2293.723	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 2624.211

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	3[illegible].000	-2356.508	1665.660	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	3[illegible].000	64.982	2292.767	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 2501.375

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	40.000	-2313.487	1708.507	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	40.000	-7.298	2291.812	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 2378.812

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	50.000	-2270.465	1751.353	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	50.000	-79.579	2290.857	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

TABLE A-2. PROGRAM PRINTOUT FOR EXAMPLE 1 (CONTINUED)

DI[illegible] SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 2?6.335

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	6[illegible].0?	-2227.443	1794.200	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	6[illegible].?0?	-151.859	2289.902	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 2133.956

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	7?.?00	-2184.421	1837.046	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	7?.?00	-224.139	2288.947	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 2011.696

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	8?.?00	-2141.399	1879.893	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	8?.?00	-296.419	2287.992	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1899.576*

TABLE A-2. PROGRAM PRINTOUT FOR EXAMPLE 1 (CONTINUED)

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 3256.335

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	60.200	-2227.443	1794.200	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	60.200	-151.859	2289.902	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 2133.956

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	70.200	-2184.421	1837.046	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	70.200	-224.139	2288.947	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 2011.696

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	80.200	-2141.399	1879.893	11.795	44.883	CONSTANT PATH	0.000000E+00	0.000000E+00
2	80.200	-296.419	2287.992	14.042	180.757	CONSTANT PATH	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1889.576*

TABLE A-2. PROGRAM PRINTOUT FOR EXAMPLE 1 (CONTINUED)

SHIP 1 TURNING PARAMETERS
LENGTH OF ADVANCE = 83.793 (METERS)
RADIUS OF THE TURN =1052.397 (METERS)
VELOCITY DURING THE TURN = 12.962 (KNOTS)

SHIP 2 TURNING PARAMETERS
LENGTH OF ADVANCE = 98.013 (METERS)
RADIUS OF THE TURN = 861.753 (METERS)
VELOCITY DURING THE TURN = 12.674 (KNOTS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	90.200	-2098.377	1922.739	11.795	44.883	ADVANCE	0.000000E+00	0.000000E+00
2	90.200	-368.699	2287.037	14.042	180.757	ADVANCE	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1767.625*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	100.200	-2055.355	1965.586	11.795	44.883	ADVANCE	0.000000E+00	0.000000E+00
2	100.200	-439.136	2285.938	12.674	181.890	RIGHT TURN	0.000000E+00	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1647.662*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	110.200	-2013.832	2006.084	10.962	42.939	LEFT TURN	0.000000E+00	0.000000E+00
2	110.200	-504.197	2281.321	12.674	186.227	RIGHT TURN	0.000000E+00	0.000000E+00

TABLE A-2. PROGRAM PRINTOUT FOR EXAMPLE 1 (CONTINUED)

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 757.822*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	190.000	-1617.783	2264.712	12.513	29.812	ACCELERATION	0.141561E-06	0.000000E+00
2	190.000	-975.270	2075.727	12.674	220.929	RIGHT TURN	0.141561E-06	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 669.729*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	200.000	-1561.461	2296.983	12.706	29.812	ACCELERATION	0.751102E-03	0.000000E+00
2	200.000	-1022.897	2031.162	12.674	225.267	RIGHT TURN	0.751102E-03	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 600.593*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
1	210.000	-1504.279	2329.748	12.899	29.812	ACCELERATION	0.968383E-01	0.000000E+00
2	210.000	-1072.648	1980.001	14.042	225.835	REVERSE TIME	0.968383E-01	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 555.544*

TABLE A-2. PROGRAM PRINTOUT FOR EXAMPLE 1 (CONTINUED)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
2	220.000	-1122.670	1928.499	13.736	225.835	DECELERATION	0.968323E-01	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)	P(GROUNDING)
2	230.000	-1171.077	1878.661	13.261	225.835	DECELERATION	0.968323E-01	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

TABLE A-3. FREQUENCY DISTRIBUTION FOR EXAMPLE 1

C.P.A. FREQUENCY DISTRIBUTION
INTERVAL SIZE = 40.00000 (METERS)
MAXIMUM NUMBER OF OCCURENCES = 1

40.00000	0	.	.
80.00000	0	.	.
120.00000	0	.	.
160.00000	0	.	.
200.00000	0	.	.
240.00000	0	.	.
280.00000	0	.	.
320.00000	0	.	.
360.00000	0	.	.
400.00000	0	.	.
440.00000	0	.	.
480.00000	0	.	.
520.00000	0	.	.
560.00000	1	.	*
600.00000	0	.	.
640.00000	0	.	.
680.00000	0	.	.
720.00000	0	.	.
760.00000	0	.	.
800.00000	0	.	.
840.00000	0	.	.
880.00000	0	.	.
920.00000	0	.	.
960.00000	0	.	.
1000.00000	0	.	.
1040.00000	0	.	.
1080.00000	0	.	.
1120.00000	0	.	.
1160.00000	0	.	.
1200.00000	0	.	.
1240.00000	0	.	.
1280.00000	0	.	.
1320.00000	0	.	.
1360.00000	0	.	.
1400.00000	0	.	.
1440.00000	0	.	.
1480.00000	0	.	.
1520.00000	0	.	.
1560.00000	0	.	.
1600.00000	0	.	.
1640.00000	0	.	.
1680.00000	0	.	.
1720.00000	0	.	.
1760.00000	0	.	.
1800.00000	0	.	.
1840.00000	0	.	.
1880.00000	0	.	.
1920.00000	0	.	.
1960.00000	0	.	.
2000.00000	0	.	.

APPENDIX B

EXECUTION EXAMPLE 2

Example 2 shows the probability of collision calculations and the multiple run option. Two different time intervals are used.

The frequency distribution plot at the end of each run contains the number of times ships approached each other within the distance specified by the interval. The interval is given on the left, and the number of occurrences is given next to the interval. The maximum number of occurrences is the maximum in any interval. It is also the value at the right-most dotted line. The dotted line in the center is the midpoint between 0 and the maximum number of occurrences.

The data in Table B-1 are divided into numbered groups. The group numbers localize the data to cards which form the card groups of Figure 3-1. Thus, for example, the data in Table B-1 contained in group bracket 3 are also on cards contained in the group of Figure 3-1 marked 3 (and hence related to ship's name, characteristics, and initial conditions).

TABLE B-1. INPUT DATA FOR EXAMPLE 2

```
    2
    3    1
    6    5
-0.1700000E+05-0.9000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.8000000E+04-0.9000000E+04 0.10000000E+01-0.70710675E+00 0.70710680E+00
 0.1300000E+05-0.4000000E+04-0.3000000E+01-0.94868331E+00-0.31622772E+00
 0.8000000E+04 0.1100000E+05-0.16666667E+01-0.16439906E+00-0.98639391E+00
-0.2200000E+05 0.1600000E+05-0.4999999E+01 0.98058069E+00 0.19611611E+00
-0.1700000E+05-0.9000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.99999994E+03-0.4000000E+04 0.15000000E+01-0.83205028E+00 0.55470022E+00
 0.3000000E+04-0.1000000E+04-0.33333334E+00-0.31622781E+00-0.94868328E+00
 0.0000000E+00 0.0000000E+00 0.2000000E+01 0.89442717E+00-0.44721363E+00
-0.2000000E+04-0.4000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.99999994E+03-0.4000000E+04 0.15000000E+01-0.83205028E+00 0.55470022E+00
    5    1                                                              1*
    5    6
-0.1750000E+05-0.7000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
 0.8000000E+04-0.7000000E+04-0.36000000E+01-0.96351793E+00-0.26764381E+00
 0.3200000E+04 0.1100000E+05-0.99999999E-15 0.00000000E+00-0.10000000E+01
-0.2100000E+05 0.1100000E+05-0.51428572E+01 0.98161539E+00 0.19086962E+00
-0.1750000E+05-0.7000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
-0.2000000E+04-0.6000000E+04 0.25000000E+00-0.24253559E+00 0.97014251E+00
 0.2000000E+04-0.5000000E+04 0.13333334E+01-0.80000000E+00 0.60000001E+00
 0.4999999E+04-0.1000000E+04-0.60000001E+00-0.51449579E+00-0.85749289E+00
 0.0000000E+00 0.2000000E+04 0.15000000E+01 0.83205026E+00-0.55470023E+00
-0.4000000E+04-0.4000000E+04-0.99999999E+00 0.70710680E+00 0.70710677E+00
-0.2000000E+04-0.6000000E+04 0.25000000E+00-0.24253559E+00 0.97014251E+00
    2    2    0    2    2      .9          2000.          0   50
     100.          15.          1                                      2
     125.           5.          1
ORE MERCURY
 0.8020000E+03  0.1104000E+03  0.4030000E+02  0.1850000E+02  0.1576000E+05
 0.6827000E+04  0.4320000E+05  0.2000000E+00  0.2800000E+02  0.2163903E+06  3
 0.1424764E+05  0.3699762E-02  0.6042567E-01  0.1536272E+02  0.3158126E+07
 0.2958737E+03  0.6392429E+05  0.1994616E+00 -0.8658371E-01  0.7388185E-02
   1.6          100.
   0.           125.          -610.          2130.
   2                                                                    4
  13.           225.
   1
1    1220.
S. S. PERcEPO_IS
 0.7540700E+03  0.1051100E+03  0.5110000E+02  0.1800000E+02  0.1700000E+05
 0.6800000E+04  0.3346100E+05  0.3000000E+00  0.2500000E+02  0.2398997E+06  3
 0.9423403E+04  0.4219993E-02  0.6496147E-01  0.1073325E+02  0.2446159E+07
 0.3536257E+03  0.6051562E+05  0.2138730E+00 -0.1024249E+00  0.8048574E-02
   2.0          100.
   0.           125.          -2130.         915.
   2                                                                    4
  12.           45.
   3
1    610.
5    45.
1    610.
   2   10.      3.          1.          5.          5.          14395      5
```

*Refer to text of Appendix B for explanation of numbered group bracketing.

TABLE B-2. PROGRAM PRINTOUT FOR EXAMPLE 2, RUN NUMBER 1

SHIP.NO.	NAME
1	ORE MERCURY
2	S. S. PERSEPOLIS

SHIP	HUMAN FACTOR	NAV. CAP. (METERS)	START X (METERS)	START Y (METERS)	START HEAD. (DEGREES)	START VEL. (KNOTS)	START TIME (SECS)	END TIME (SECS)
1	1.60	100.00	-610.00	2130.00	225.00	13.00	0.00	185.00
2	2.00	100.00	-2130.00	915.00	45.00	12.00	0.00	185.00

SHIP CHARACTERISTICS

1

0.8000000E+03	0.1104000E+03	0.4030000E+02	0.1850000E+02	0.1576000E+05
0.6807000E+04	0.4320000E+05	0.2000000E+00	0.2000000E+02	0.2143003E+06
0.1424764E+05	0.3699762E-02	0.6082567E-01	0.1536272E+02	0.3158126E+07
0.2958737E+03	0.6392429E+05	0.1994616E+00	-0.8658371E-01	0.7388188E-02

2

0.7540700E+03	0.1051100E+03	0.5110000E+02	0.1800000E+02	0.1700000E+05
0.6800000E+04	0.3346100E+05	0.3000000E+00	0.2500000E+02	0.8390997E+06
0.9423403E+04	0.4219993E-02	0.6496147E-01	0.1073329E+02	0.2446189E+07
0.3536257E+03	0.6051562E+05	0.2138730E+00	-0.1024249E+00	0.8048574E-02

SHIP COMMANDS

1

STRAIGHT AHEAD FOR 1220.00 METERS

2

STRAIGHT AHEAD FOR 610.00 METERS
TURN RIGHT 45.00 DEGREES
STRAIGHT AHEAD FOR 610.00 METERS

****
* *
* RUN NUMBER 1 *
* *
****

TABLE B-2. PROGRAM PRINTOUT FOR EXAMPLE 2, RUN NUMBER 1 (CONTINUED)

SHIP	SHIP NAV. CAP. (METERS)	START X (METERS)	START Y (METERS)	START HEAD. (DEGREES)	START VEL. (KNOTS)	START TIME (SECS)	END TIME (SECS)
1	153	-552.35	2146.93	224.41	12.78	0.00	125.00
2	205	-2230.25	984.15	45.34	11.73	0.00	125.00

SHIP	COMMANDS
1	
	STRAIGHT AHEAD FOR 1239.10 METERS
2	
	STRAIGHT AHEAD FOR 613.16 METERS
	TURN RIGHT 45.05 DEGREES
	STRAIGHT AHEAD FOR 622.83 METERS

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	15.000	-622.827	2077.878	12.778	224.415	CONSTANT PATH	0.000000E+00
2	15.000	-2166.604	1048.557	11.726	45.339	CONSTANT PATH	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1855.464*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	30.000	-693.304	2008.826	12.778	224.415	CONSTANT PATH	0.000000E+00
2	30.000	-2102.956	1112.961	11.726	45.339	CONSTANT PATH	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1670.237*

TABLE B-2. PROGRAM PRINTOUT FOR EXAMPLE 2, RUN NUMBER 1 (CONTINUED)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	45.000	-763.782	1939.775	12.778	224.415	CONSTANT PATH	0.000000E+00
2	45.000	-2039.309	1177.365	11.726	45.339	CONSTANT PATH	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1486.014*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	60.000	-834.259	1870.723	12.778	224.415	CONSTANT PATH	0.000000E+00
2	60.000	-1975.662	1241.770	11.726	45.339	CONSTANT PATH	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1303.220*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	75.000	-904.736	1801.671	12.778	224.415	CONSTANT PATH	0.000000E+00
2	75.000	-1912.014	1306.174	11.726	45.339	CONSTANT PATH	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1122.554*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	90.000	-975.214	1732.619	12.778	224.415	CONSTANT PATH	0.986497E-05
2	90.000	-1848.367	1370.578	11.726	45.339	CONSTANT PATH	0.986497E-05

TABLE B-2. PROGRAM PRINTOUT FOR EXAMPLE 2, RUN NUMBER 1 (CONTINUED)

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 945.236*

SHIP 2 TURNING PARAMETERS
LENGTH OF ADVANCE = 54.209 (METERS)
RADIUS OF THE TURN = 999.064 (METERS)
VELOCITY DURING THE TURN = 10.932 (KNOTS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	105.000	-1045.691	1663.567	12.778	224.415	CONSTANT PATH	0.161817E-02
2	105.000	-1784.720	1434.982	11.726	45.339	ADVANCE	0.161817E-02

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 773.573*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	110.000	-1069.184	1640.550	12.778	224.415	CONSTANT PATH	0.178814E-02
2	110.000	-1763.504	1456.450	11.726	45.339	ADVANCE	0.178814E-02

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 718.313*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	115.000	-1092.676	1617.533	12.778	224.415	CONSTANT PATH	0.219771E-02
2	115.000	-1743.791	1476.843	10.932	46.773	RIGHT TURN	0.219771E-02

TABLE B-2. PROGRAM PRINTOUT FOR EXAMPLE 2, RUN NUMBER 1 (CONTINUED)

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 945.236*

SHIP 2 TURNING PARAMETERS
LENGTH OF ADVANCE = 54.209 (METERS)
RADIUS OF THE TURN = 999.064 (METERS)
VELOCITY DURING THE TURN = 10.932 (KNOTS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	105.200	-1045.691	1663.567	12.778	224.415	CONSTANT PATH	0.161017E-02
2	105.200	-1784.720	1434.982	11.726	45.339	ADVANCE	0.161017E-02

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 773.573*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	110.200	-1069.184	1640.550	12.778	224.415	CONSTANT PATH	0.170214E-02
2	110.200	-1763.504	1456.450	11.726	45.339	ADVANCE	0.170214E-02

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 718.313*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	115.200	-1092.676	1617.533	12.778	224.415	CONSTANT PATH	0.215771E-02
2	115.200	-1743.791	1476.843	10.932	46.773	RIGHT TURN	0.215771E-02

TABLE B-2. PROGRAM PRINTOUT FOR EXAMPLE 2, RUN NUMBER 1 (CONTINUED)

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 666.141*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	120.000	-1116.168	1594.516	12.778	224.415	CONSTANT PATH	0.397855E-02
2	120.000	-1724.811	1497.613	10.932	48.386	RIGHT TURN	0.397855E-02

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 616.308*

TABLE B-3. FREQUENCY DISTRIBUTION FOR EXAMPLE 2, RUN NUMBER 1

C.P.A. FREQUENCY DISTRIBUTION
INTERVAL SIZE = 40.00000 (METERS)
MAXIMUM NUMBER OF OCCURENCES = 1

40.00000	0*	.	.
80.00000	0*	.	.
120.00000	0*	.	.
160.00000	3*	.	.
200.00000	0*	.	.
240.00000	0*	.	.
280.00000	0*	.	.
320.00000	0*	.	.
360.00000	0*	.	.
400.00000	0*	.	.
440.00000	0*	.	.
480.00000	0*	.	.
520.00000	0*	.	.
560.00000	0*	.	.
600.00000	1.	.	.
640.00000	0*	.	.
680.00000	0*	.	.
720.00000	0*	.	.
760.00000	0*	.	.
800.00000	0*	.	.
840.00000	0*	.	.
880.00000	0*	.	.
920.00000	0*	.	.
960.00000	0*	.	.
1000.00000	0*	.	.
1040.00000	0*	.	.
1080.00000	0*	.	.
1120.00000	0*	.	.
1160.00000	0*	.	.
1200.00000	0*	.	.
1240.00000	0*	.	.
1280.00000	0*	.	.
1320.00000	0*	.	.
1360.00000	0*	.	.
1400.00000	0*	.	.
1440.00000	0*	.	.
1480.00000	0*	.	.
1520.00000	0*	.	.
1560.00000	0*	.	.
1600.00000	0*	.	.
1640.00000	0*	.	.
1680.00000	0*	.	.
1720.00000	0*	.	.
1760.00000	0*	.	.
1800.00000	0*	.	.
1840.00000	0*	.	.
1880.00000	0*	.	.
1920.00000	0*	.	.
1960.00000	0*	.	.
2000.00000	0*	.	.

TABLE B-4. PROGRAM PRINTOUT FOR EXAMPLE 2, RUN NUMBER 2

```
**********************
*                    *
*  RUN NUMBER  2     *
*                    *
**********************
```

SHIP	SHIP NAV. CAP. (METERS)	START X (METERS)	START Y (METERS)	START HEAD. (DEGREES)	START VEL. (KNOTS)	START TIME (SECS)	END TIME (SECS)
1	163	-601.95	2166.82	225.58	13.02	0.00	125.00
2	199	-1938.33	970.29	44.75	11.70	0.00	125.00

SHIP	COMMANDS
1	
	STRAIGHT AHEAD FOR 1211.50 METERS
2	
	STRAIGHT AHEAD FOR 638.42 METERS
	TURN RIGHT 45.41 DEGREES
	STRAIGHT AHEAD FOR 604.18 METERS

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	15.000	-672.307	2095.027	13.019	225.579	CONSTANT PATH	0.0000000E+00
2	15.000	-1874.174	1033.881	11.698	44.747	CONSTANT PATH	0.0000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1603.282*

TABLE B-4. PROGRAM PRINTOUT FOR EXAMPLE 2, RUN NUMBER 2 (CONTINUED)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	30.200	-742.668	2023.230	13.019	225.579	CONSTANT PATH	0.000000E+00
2	30.200	-1810.022	1097.468	11.698	44.747	CONSTANT PATH	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1412.898*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	45.200	-813.032	1951.432	13.019	225.579	CONSTANT PATH	0.000000E+00
2	45.200	-1745.871	1161.054	11.698	44.747	CONSTANT PATH	0.000000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1222.657*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	60.200	-883.391	1879.635	13.019	225.579	CONSTANT PATH	0.458811E-08
2	60.200	-1681.720	1224.641	11.698	44.747	CONSTANT PATH	0.458811E-08

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 1032.641*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)

TABLE B-4. PROGRAM PRINTOUT FOR EXAMPLE 2, RUN NUMBER 2 (CONTINUED)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	110.000	-1117.929	1640.312	13.019	225.579	CONSTANT PATH	0.733389E+00
2	110.000	-1467.882	1436.596	11.698	44.747	ADVANCE	0.733389E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 404.929*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	115.000	-1141.383	1616.379	13.019	225.579	CONSTANT PATH	0.858182E+00
2	115.000	-1446.514	1457.776	10.989	44.744	RIGHT TURN	0.858182E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 343.890*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	120.000	-1164.836	1592.447	0.000	225.579	CONSTANT PATH	0.942181E+00
2	120.000	-1426.858	1477.826	0.000	46.371	CONSTANT PATH	0.942181E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 285.995*

TABLE B-4. PROGRAM PRINTOUT FOR EXAMPLE 2, RUN NUMBER 2 (CONTINUED)

1	75.000	-953.752	1807.838	13.019	225.579	CONSTANT PATH	0.268750E-02
2	75.000	-1617.568	1288.228	11.698	44.747	CONSTANT PATH	0.268750E-02

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 842.999*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	90.000	-1024.114	1736.041	13.019	225.579	CONSTANT PATH	0.115067E+00
2	90.000	-1553.417	1351.814	11.698	44.747	CONSTANT PATH	0.115067E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 654.059*

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(COLLISION)
1	105.000	-1094.475	1664.244	13.019	225.579	CONSTANT PATH	0.638247E+00
2	105.000	-1489.266	1415.481	11.698	44.747	CONSTANT PATH	0.638247E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

1 2 466.672*

SHIP 2 TURNING PARAMETERS
LENGTH OF ADVANCE = 93.739 (METERS)
RADIUS OF THE TURN =1001.132 (METERS)
VELOCITY DURING THE TURN = 10.909 (KNOTS)

TABLE B-5. FREQUENCY DISTRIBUTION FOR EXAMPLE 2, RUN NUMBER 2

C.P.A. FREQUENCY DISTRIBUTION
INTERVAL SIZE = 40.00000 (METERS)
MAXIMUM NUMBER OF OCCURENCES = 1

40.00000	0*	.	.
80.00000	0*	.	.
120.00000	0*	.	.
160.00000	0*	.	.
200.00000	0*	.	.
240.00000	0*	.	.
280.00000	0*	.	.
320.00000	1.	.	*
360.00000	0*	.	.
400.00000	0*	.	.
440.00000	0*	.	.
480.00000	0*	.	.
520.00000	0*	.	.
560.00000	0*	.	.
600.00000	0*	.	.
640.00000	0*	.	.
680.00000	0*	.	.
720.00000	0*	.	.
760.00000	0*	.	.
800.00000	0*	.	.
840.00000	0*	.	.
880.00000	0*	.	.
920.00000	0*	.	.
960.00000	0*	.	.
1000.00000	0*	.	.
1040.00000	0*	.	.
1080.00000	0*	.	.
1120.00000	0*	.	.
1160.00000	0*	.	.
1200.00000	0*	.	.
1240.00000	0*	.	.
1280.00000	0*	.	.
1320.00000	0*	.	.
1360.00000	0*	.	.
1400.00000	0*	.	.
1440.00000	0*	.	.
1480.00000	0*	.	.
1520.00000	0*	.	.
1560.00000	0*	.	.
1600.00000	0*	.	.
1640.00000	0*	.	.
1680.00000	0*	.	.
1720.00000	0*	.	.
1760.00000	0*	.	.
1800.00000	0*	.	.
1840.00000	0*	.	.
1880.00000	0*	.	.
1920.00000	0*	.	.
1960.00000	0*	.	.
2000.00000	0*	.	.

APPENDIX C

EXECUTION EXAMPLE 3

Example 3 shows the probability of grounding calculation by moving the ship close to an island.

The frequency distribution plot at the end of the run contains the number of times ships approached each other within the distance specified by the interval. The interval is given on the left, and the number of occurrences is given next to the interval. The maximum number of occurrences is the maximum in any interval. It is also the value at the right-most dotted line. The dotted line in the center is the midpoint between 0 and the maximum number of occurrences.

The Data in Table C-1 are divided into numbered groups. The group numbers localize the data to cards which form the card groups of Figure 3-1. Thus, for example, the data in Table C-1 contained in group bracket 3 are also on cards contained in the group of Figure 3-1 marked 3 (and hence related to ship's name, characteristics, and initial conditions).

TABLE C-1. INPUT DATA FOR EXAMPLE 3

```
      2
      3    1
      6    5
  -0.17000000E+05-0.90000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
   0.80000000E+04-0.90000000E+04 0.10000000E+01-0.70710675E+00 0.70710680E+00
   0.13000000E+05-0.40000000E+04-0.30000000E+01-0.94868331E+00-0.31622772E+00
   0.80000000E+04 0.11000000E+05-0.16666667E+00-0.16439906E+00-0.98639391E+00
  -0.22000000E+05 0.16000000E+05-0.49999996E+01 0.98058069E+00 0.19611611E+00
  -0.17000000E+05-0.90000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
   0.99999994E+03-0.40000000E+04 0.15000000E+01-0.83205028E+00 0.55470022E+00
   0.30000000E+04-0.10000000E+04-0.33333334E+00-0.31622781E+00-0.94868328E+00
   0.00000000E+02 0.00000000E+00 0.20000000E+01 0.89442717E+00-0.44721363E+00
  -0.20000000E+04-0.40000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
   0.99999994E+03-0.40000000E+04 0.15000000E+01-0.83205028E+00 0.55470022E+00
      5    1                                                                        1
      5    6
  -0.17500000E+05-0.70000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
   0.80000000E+04-0.70000000E+04-0.36000000E+01-0.96351793E+00-0.26764381E+00
   0.30000000E+04 0.11000000E+05-0.99999999E-15 0.00000000E+00-0.10000000E+01
  -0.21000000E+05 0.11000000E+05-0.51428572E+01 0.98161539E+00 0.19086962E+00
  -0.17500000E+05-0.70000000E+04 0.99999999E-15 0.00000000E+00 0.10000000E+01
  -0.20000000E+04-0.60000000E+04 0.25000000E+00-0.24253559E+00 0.97014251E+00
   0.20000000E+04-0.50000000E+04 0.13333334E+01-0.80000000E+00 0.60000001E+00
   0.49999999E+04-0.10000000E+04-0.60000001E+00-0.51449579E+00-0.85749289E+00
   0.00000000E+07 0.20000000E+04 0.15000000E+01 0.83205026E+00-0.55470023E+00
  -0.40000001E+04-0.40000000E+04-0.99999999E+00 0.70710680E+00 0.70710677E+00
  -0.20000000E+04-0.60000000E+04 0.25000000E+00-0.24253559E+00 0.97014251E+00
      1    1    1    2    3      .9           2000.         0   50
     240.            10.            1                                               2
   ORE MERCURY
    0.8000000E+03  0.1104000E+03  0.4030000E+02  0.1850000E+02  0.1576000E+05
    0.6807000E+04  0.4320000E+05  0.2000000E+00  0.2800000E+02  0.2163903E+06     3
    0.1424764E+05  0.3699762E-02  0.6082567E-01  0.1536272E+02  0.3158126E+07
    0.2958737E+03  0.6392429E+05  0.1994616E+00 -0.8658371E-01  0.7388185E-02
     1.6           100.
       .           200.          -1000.          0.
      2
     14.             0.                                                              4
      2
  1    700.
  5    20.
      1  10.       3.          1.          5.      5.          14395                 5
```

TABLE C-2. PROGRAM PRINTOUT FOR EXAMPLE 3

SHIP.NO.	NAME
1	ORE MERCURY

SHIP	HUMAN FACTOR	NAV. CAP. (METERS)	START X (METERS)	START Y (METERS)	START HEAD. (DEGREES)	START VEL. (KNOTS)	START TIME (SECS)	END TIME (SECS)
1	1.60	100.00	-1000.00	0.00	0.00	14.00	0.00	200.00

SHIP CHARACTERISTICS

1

0.8200000E+03	0.1104000E+03	0.4030000E+02	0.1850000E+02	0.1576000E+05
0.6807000E+04	0.4320000E+05	0.2000000E+00	0.2800000E+02	0.2163903E+06
0.1424764E+05	0.3699762E-02	0.6082567E-01	0.1536272E+02	0.3156126E+07
0.2958737E+03	0.6392429E+05	0.1994616E+00	-0.8658371E-01	0.7388185E-02

SHIP COMMANDS

1

STRAIGHT AHEAD FOR 700.00 METERS
TURN RIGHT 20.00 DEGREES

****
* *
* RUN NUMBER 1 *
* *
****

SHIP	SHIP NAV. CAP. (METERS)	START X (METERS)	START Y (METERS)	START HEAD. (DEGREES)	START VEL. (KNOTS)	START TIME (SECS)	END TIME (SECS)
1	153	-905.49	0.00	0.00	13.76	0.00	200.00

SHIP COMMANDS

TABLE C-2. PROGRAM PRINTOUT FOR EXAMPLE 3 (CONTINUED)

1

STRAIGHT AHEAD FOR 710.96 METERS
TURN RIGHT 20.09 DEGREES

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	10.000	-834.654	0.000	13.761	0.000	CONSTANT PATH	0.745858E-07

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	20.000	-763.816	0.000	13.761	0.000	CONSTANT PATH	0.355303E-05

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	30.000	-692.978	0.000	13.761	0.000	CONSTANT PATH	0.159614E-03

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	40.000	-622.140	0.000	13.761	0.000	CONSTANT PATH	0.900000E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)

TABLE C-2. PROGRAM PRINTOUT FOR EXAMPLE 3 (CONTINUED)

1	[illegible]	-551.302	0.000	13.761	0.000	CONSTANT PATH	0.750040E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	60.000	-480.464	0.000	13.761	0.000	CONSTANT PATH	0.875020E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	70.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.937510E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	80.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.968755E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	90.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.984377E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)

TABLE C-2. PROGRAM PRINTOUT FOR EXAMPLE 3 (CONTINUED)

1	[illegible]	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.992189E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	110.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.996094E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	120.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.998047E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	130.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.999024E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	140.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.999512E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

TABLE C-2. PROGRAM PRINTOUT FOR EXAMPLE 3 (CONTINUED)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	150.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.999756E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	160.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.999878E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	170.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.999939E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	180.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.999969E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	190.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.999985E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

TABLE C-2. PROGRAM PRINTOUT FOR EXAMPLE 3 (CONTINUED)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	200.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.999992E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

SHIP NO.	TIME (SECS)	X (METERS)	Y (METERS)	VELOCITY (KNOTS)	HEADING (DEGREES)	MANEUVER	P(GROUNDING)
1	210.000	-409.626	0.000	0.000	0.000	CONSTANT PATH	0.999999E+00

DISTANCES BETWEEN SHIPS,* INDICATES SHIPS WITHIN RADIUS OF 2000.00 (METERS)

TABLE C-3. FREQUENCY DISTRIBUTION FOR EXAMPLE 3

C.P.A. FREQUENCY DISTRIBUTION
INTERVAL SIZE = 40.00000 (METERS)
MAXIMUM NUMBER OF OCCURENCES = 0

40.00000	0*	.	.
80.00000	0*	.	.
120.00000	0*	.	.
160.00000	0*	.	.
200.00000	0*	.	.
240.00000	0*	.	.
280.00000	0*	.	.
320.00000	0*	.	.
360.00000	0*	.	.
400.00000	0*	.	.
440.00000	0*	.	.
480.00000	0*	.	.
520.00000	0*	.	.
560.00000	0*	.	.
600.00000	0*	.	.
640.00000	0*	.	.
680.00000	0*	.	.
720.00000	0*	.	.
760.00000	0*	.	.
800.00000	0*	.	.
840.00000	0*	.	.
880.00000	0*	.	.
920.00000	0*	.	.
960.00000	0*	.	.
1000.00000	0*	.	.
1040.00000	0*	.	.
1080.00000	0*	.	.
1120.00000	0*	.	.
1160.00000	0*	.	.
1200.00000	0*	.	.
1240.00000	0*	.	.
1280.00000	0*	.	.
1320.00000	0*	.	.
1360.00000	0*	.	.
1400.00000	0*	.	.
1440.00000	0*	.	.
1480.00000	0*	.	.
1520.00000	0*	.	.
1560.00000	0*	.	.
1600.00000	0*	.	.
1640.00000	0*	.	.
1680.00000	0*	.	.
1720.00000	0*	.	.
1760.00000	0*	.	.
1800.00000	0*	.	.
1840.00000	0*	.	.
1880.00000	0*	.	.
1920.00000	0*	.	.
1960.00000	0*	.	.
2000.00000	0*	.	.