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SHIPBOARD TROPICAL CYCLONE APPLICATIONS SOFTWARE SYSTEM FOR THE ETC(U)
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SHIPBOARD TROPICAL CYCLONE APPLICATIONS SOFTWARE SYSTEM FOR THE WESTERN NORTH PACIFIC OCEAN

Prepared By:

Don Chin

Systems and Applied Sciences Corporation
Monterey, California 93940

Contract No. N00228-81-C-H157

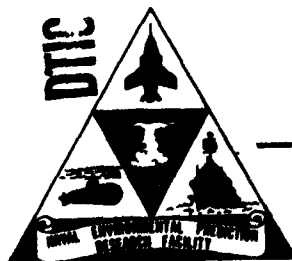
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The shipboard Tropical Cyclone Applications Software System (TCASS) is described. TCASS is a set of microcomputer programs which displays and evaluates the tropical cyclone wind threat to a ship or unit. Tropical cyclone wind probability forecast methods for the western North Pacific Ocean, based on statistical analyses of historical tropical cyclone forecast errors, are used within TCASS. If the tropical cyclone wind threat exceeds a predefined threshold level, an alternative routing procedure ((continued on reverse))			

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Block 20, Abstract, continued.

is invoked to reduce the threat level. Applications of the software are provided, and examples of the resulting output are included.



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SECTION 1. INTRODUCTION

1.1 Background. Tropical cyclone strike and wind probability forecast methods have been developed based on statistical analyses of historical Joint Typhoon Warning Center (JTWC), Guam tropical cyclone forecast errors for the western North Pacific Ocean as described in references [1] and [2]. These forecast techniques provide a quantified measure of the tropical cyclone wind threat to fixed points of interest, and have been adapted for use in developing a set of computer programs for Optimum Track Ship Routing (OTSR) applications which was reported in reference [3]. This OTSR applications software is currently installed on the large mainframe computer system at the Fleet Numerical Oceanography Center (FNOC), Monterey, California.

Similar software was needed for shipboard applications which allow independence from central site computer systems. As a result, the Tropical Cyclone Applications Software System (TCASS) was developed for the Naval Environmental Prediction Research Facility (NEPRF). The initial version of TCASS, applicable to the western North Pacific Ocean area, was written for the Hewlett-Packard (HP) 9845 and has been distributed to Pacific Fleet HP9845 equipped ships as Shipboard Numerical Aids Program (SNAP) No. 7.

A typical shipboard unit of the HP9845 desktop microcomputer, illustrated in Figure 1-01, has a keyboard, cathode ray tube (CRT), two tape cassette drives, a thermal printer, graphics capabilities, and 64K words of memory.

1.2 Capabilities. TCASS applies tropical cyclone wind probability forecast techniques based on the JTWC Guam tropical cyclone warnings to:

- a. provide briefing aids
- b. assist the shipboard user in evaluating the tropical

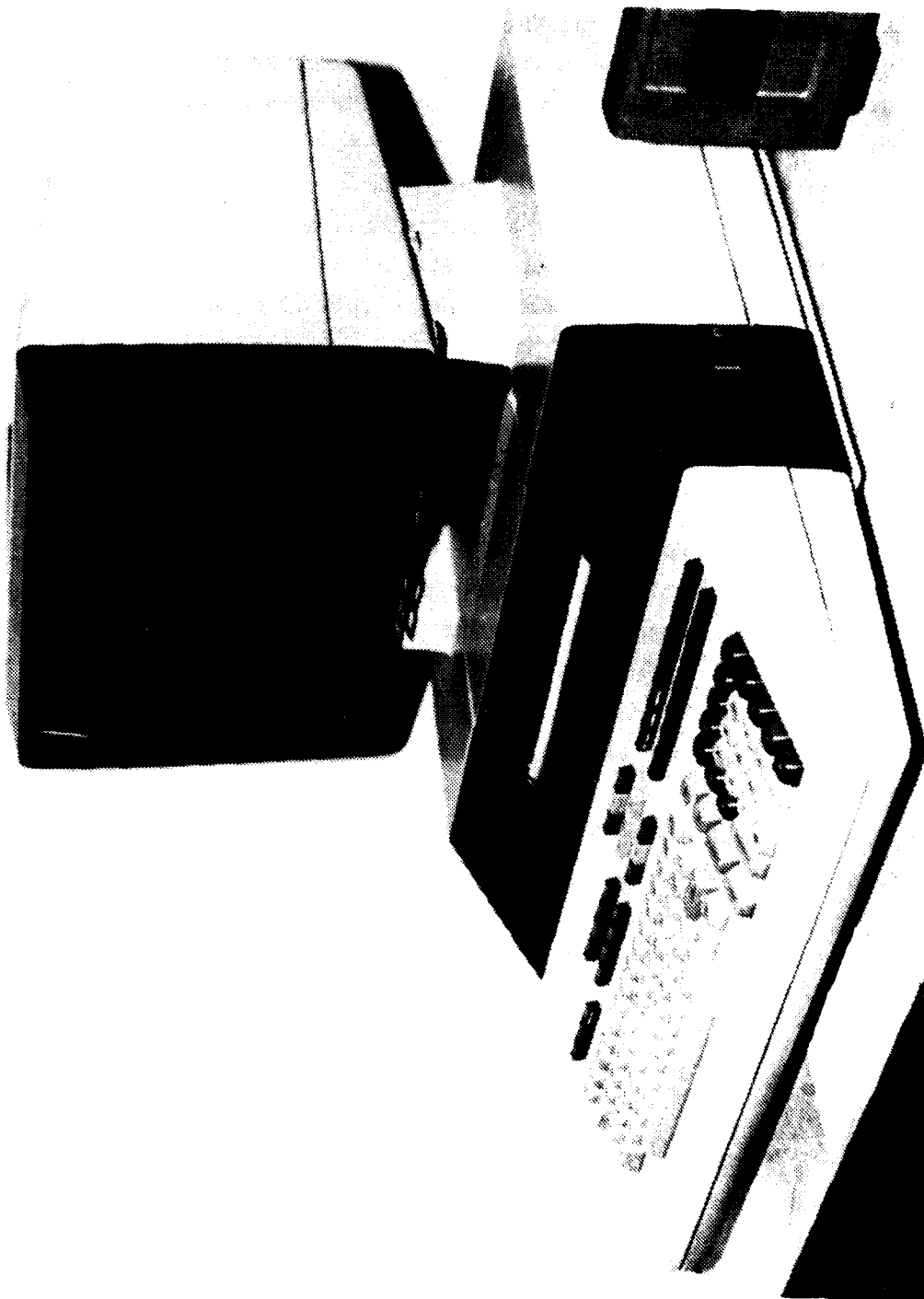


FIGURE 1-01. Typical HP9845 Microcomputer Unit

cyclone wind threat

- c. assist in formulating a recommended course of action

To accomplish this, TCASS provides six options which perform six corresponding functions, as follows:

Option 1. Display the current tropical cyclone warning in graphic and alphanumeric form.

Option 2. Display the "danger" area¹ for the warning as defined by Annex H of the CINCPACFLT operation order No. 201.

Option 3. Display projected ship tracks beginning at the date-time-group of the warning for the duration of the warning period up to 72 hours.

Option 4. Evaluate a ship's projected track by calculating the instantaneous probabilities of encountering 30 and 50 kt tropical cyclone winds at 6 hour intervals along the ship's projected track for a given warning during the warning period.

Option 5. Calculate and display the user specified critical probability² isolines for 30 and/or 50 kt tropical cyclone winds at 24 hr intervals for the warning.

Option 6. Calculate and display the shortest route (auto-routing), from the ship's position at the beginning

¹ The CINCPACFLT "danger" area is determined from the JTWC warning by constructing the area of 30 kt winds at the warning time, the area of 30 kt winds at the 24 hr forecast position increased by a radius of 135 n mi, and connecting the two areas by tangent lines to produce a contiguous area.

² Critical probabilities are those threshold values designated by the user which, if exceeded, constitutes an unacceptable level of risk. For example, a critical probability of 10% indicates a 90% probability of avoiding the occurrence of the event is acceptable.

of the warning period toward a position designated by the user, which does not exceed the user specified critical probabilities of 30 and 50 kt tropical cyclone winds during the period of the warning.

SECTION 2. DESCRIPTION

2.1 Modes of Operation. TCASS operates in two modes:

- a. semi-automatic mode
- b. selective mode

Semi-automatic mode. In this mode, TCASS performs all six functions described in the previous section. A minimum of user interaction is necessary and is mainly performed at the beginning of processing in order to enter data. However, this mode limits the processing to one tropical cyclone warning and one projected ship track during each run. Results are displayed and hard copies of the products are provided automatically.

Selective mode. The selective mode allows the user a wider range of flexibility. The six options, corresponding to the functions performed by TCASS, may be selected individually or in combination as desired by the user during a given TCASS run in this mode. Up to three tropical cyclone warnings may be processed. Any number of projected ship tracks may be displayed at the option of the user. However, only one ship at a time may be evaluated or auto-routed for each tropical cyclone warning. TCASS also allows the user to obtain hard copies of the output as desired. Upon completion of program execution in either mode the user may re-run the program selecting a different mode or different options in the selective mode.

2.2 Map Background. The total area of coverage for TCASS graphic displays extends from 3°N to 37°N, 105°E to 175°E. Because of the limitations of the graphic display area, coverage of the above area is provided by two overlapping backgrounds, a left panel and a right panel. These are illustrated in Figures 2-01 and 2-02, respectively. The user may select either panel, otherwise the left panel will be used by default.

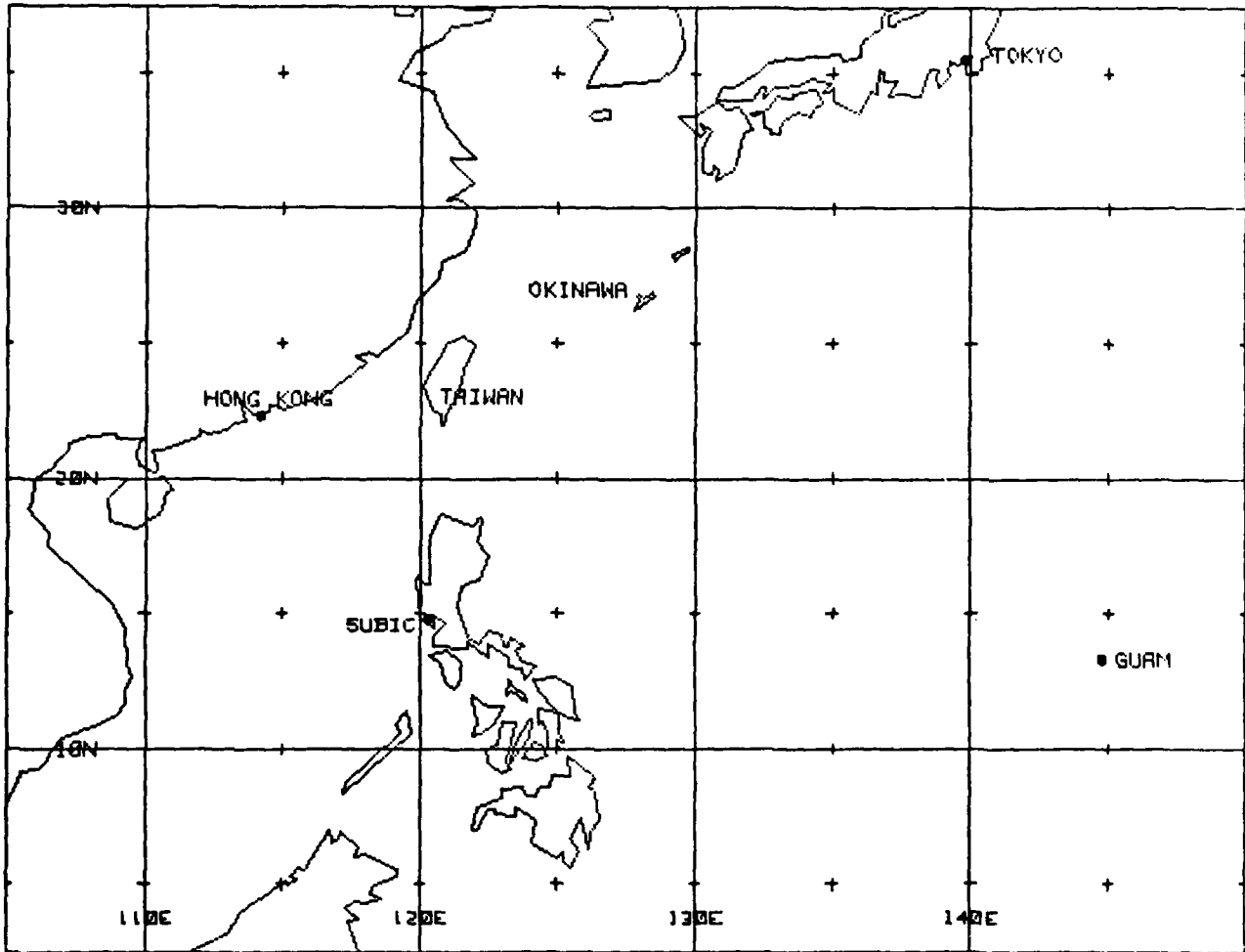


FIGURE 2-01. Geographic Background -
Left Panel.

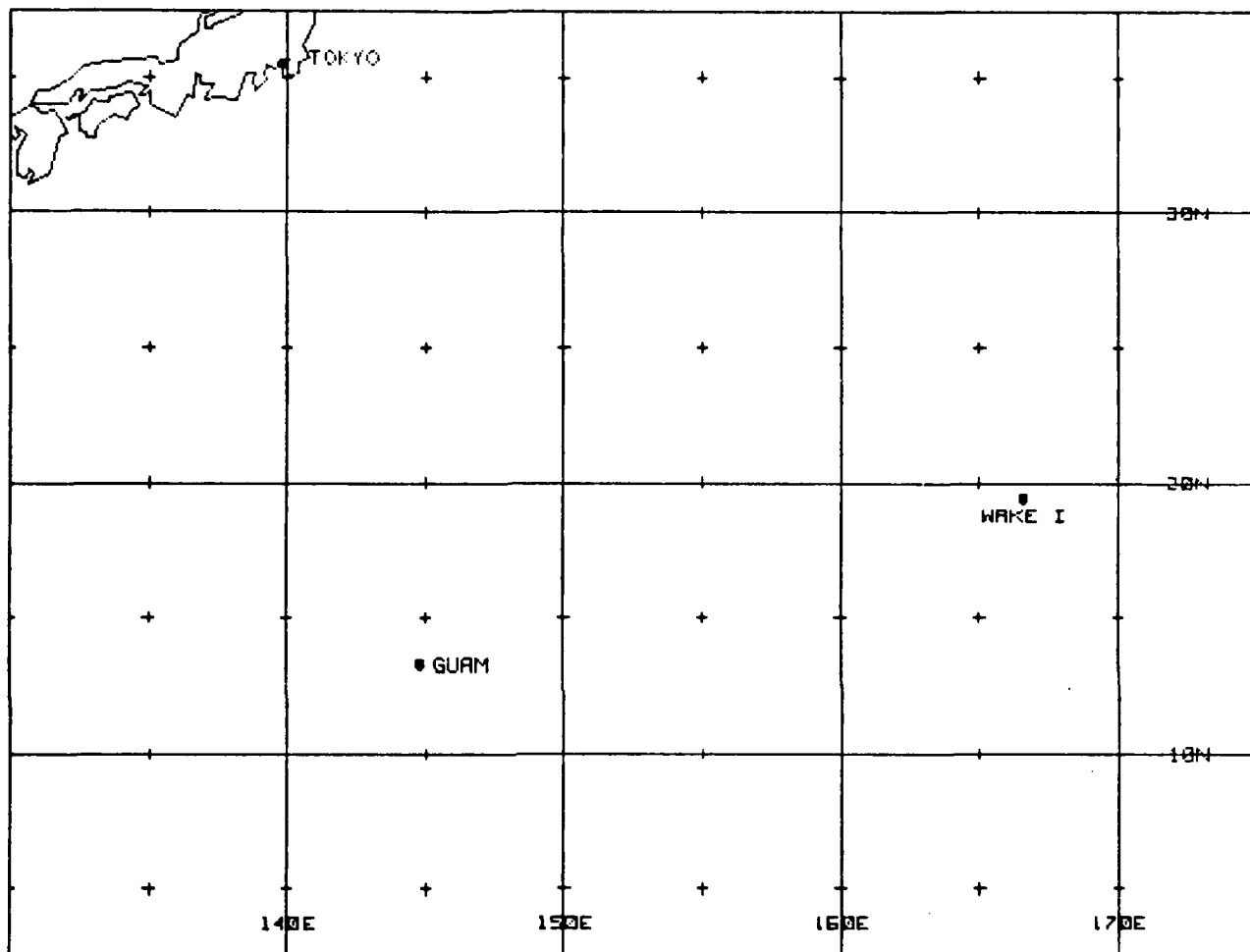


FIGURE 2-02. Geographic Background -
Right Panel.

SECTION 3. PROGRAM OPERATION

3.1 General. Detailed operating instructions for TCASS are contained in the TCASS Users Manual, reference [4]. This section covers the input data needed in the operation of TCASS, the processing of each function and the resulting outputs.

3.2 Input Data. To operate TCASS certain input data are needed. The program prompts the user on the information required (depending on the mode of operation and options selected), and the format of the data entries. The current JTWC Guam tropical cyclone warning(s), the ship's position at warning time, and other ship information such as speed of advanced and course or projected track are normally required. The critical probabilities (threshold values) of 30 and 50 kt tropical cyclone winds, respectively, may also be necessary. These user defined critical probabilities indicate the level of risk that is considered acceptable for the operating circumstances. In the absence of user specified critical values, the program assigns (by default) values of 5% and 3% probabilities of 30 and 50 kt tropical cyclone winds, respectively. The above default values may be interpreted to mean a 95% and 97% level of confidence of avoiding 30 and 50 kt winds.

3.3 Processing and Output. TCASS processing depends on the operating mode and options selected. Each option and the resulting output are described in this subsection.

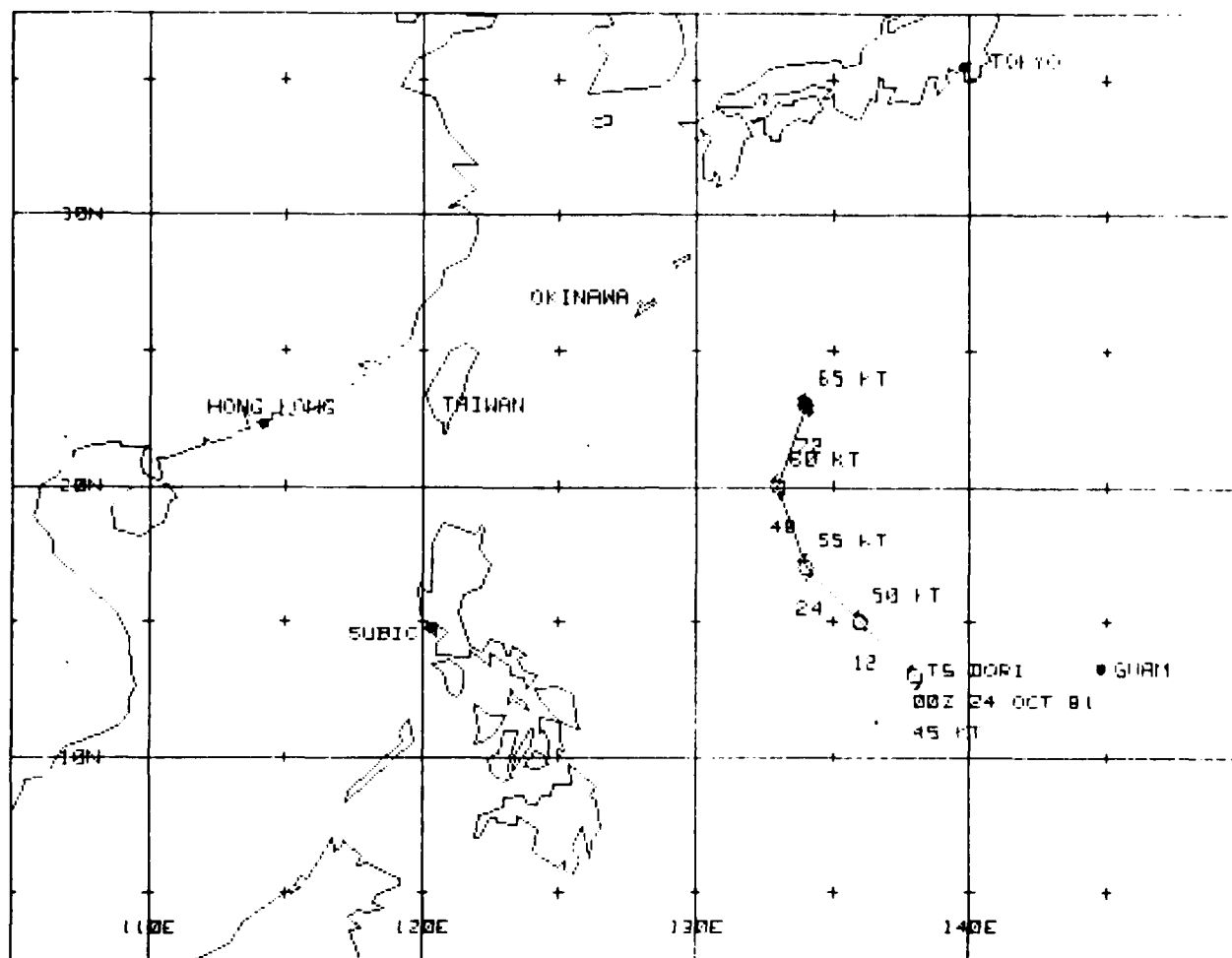
Option 1. Display tropical cyclone warning(s). To accomplish this, TCASS requests the necessary JTWC tropical cyclone warning data and plots the current, 12, 24, 48 and 72 hour warning positions (as available) of the tropical cyclone using the appropriate tropical cyclone symbols, with the

projected warning track connecting the warning positions. Appropriate annotations of the tropical cyclone stage, cyclone name or number, the warning date-time, and the maximum winds for each position are provided. An example of the display resulting from the selection of Option 1 is shown in Figure 3-01.

Option 2. Display "danger" area(s). Upon selection of this option, Option 1 is automatically selected, if not already specified, to request the necessary warning data and plot the tropical cyclone warning(s). The "danger" area, described earlier, is constructed and plotted. Figure 3-02 illustrates the result of selecting Option 2.

Option 3. Display ship track(s). With this option, the user is prompted to enter ship information consisting of the ship's call sign or 4 character designator, position at warning time, average speed, and the ship's projected track in the form of a base course or up to 4 additional positions which define the projected track. Using this information the ship's projected track is calculated at 6 hour intervals and plotted. An example is provided in Figure 3-03. The initial position of the track, subsequent 24 hourly positions, and final position are designated by an "X", with the > symbol designating the 6 hourly intermediate positions and direction of movement. An alphanumeric tabular display is also available as shown in Figure 3-04.

Option 4. Evaluate ship's projected track. When this option is invoked, the program requests the tropical cyclone warning data and ship's data as in Options 1 and 3. Once these data are entered and the user designated critical probabilities specified, if different from the default values, the program calculates the instantaneous probabilities of encountering 30 and 50 kt tropical cyclone winds at 6 hour intervals along the projected track. If the critical values



WARNING DTG: 12Z 24 OCT 81

TROPICAL STORM DORI WARNING NR 4 DIR SPD 310 DEGREES 9 KTS
 00 HR INITIAL POSITION 1300N 13800E MAX WIND 45 KT
 RADIUS OF 30 KT WINDS 100 MILES NE SEMICIRCLE, 75 MILES ELSEWHERE
 12 HR FORECAST POSITION 1500N 13600E MAX WIND 50 KT
 24 HR FORECAST POSITION 1700N 13400E MAX WIND 55 KT
 RADIUS OF 50 KT WINDS 30 MILES
 RADIUS OF 30 KT WINDS 150 MILES NE SEMICIRCLE, 100 MILES ELSEWHERE
 48 HR FORECAST POSITION 2000N 13300E MAX WIND 60 KT
 RADIUS OF 50 KT WINDS 50 MILES
 72 HR FORECAST POSITION 2300N 13400E MAX WIND 65 KT
 RADIUS OF 50 KT WINDS 75 MILES

FIGURE 3-01. Example of Option 1 output showing the tropical cyclone warning display in graphic and alphanumeric form.

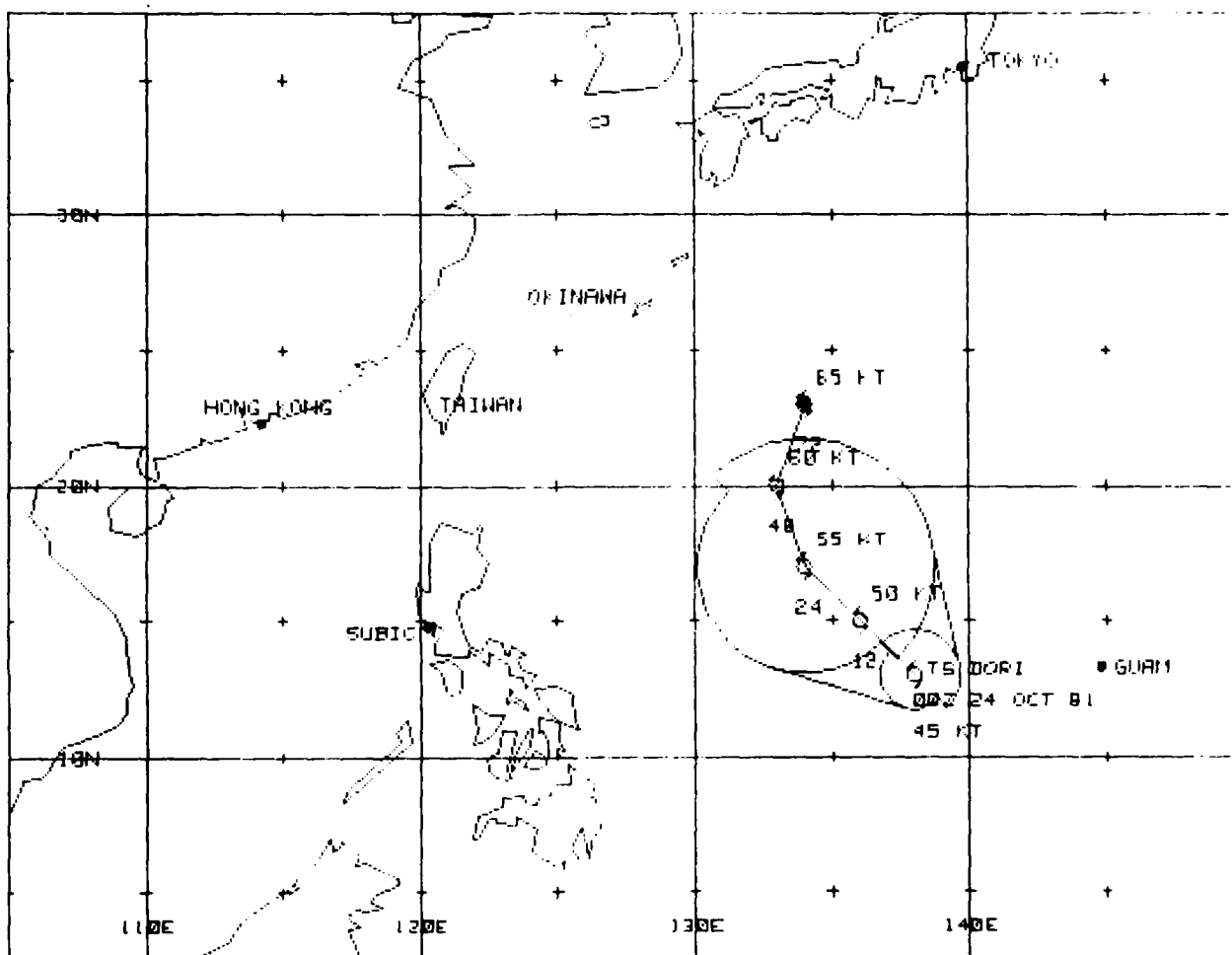


FIGURE 3-02. Example of Option 2 output consisting of a graphic display of the tropical cyclone warning and "danger" area.

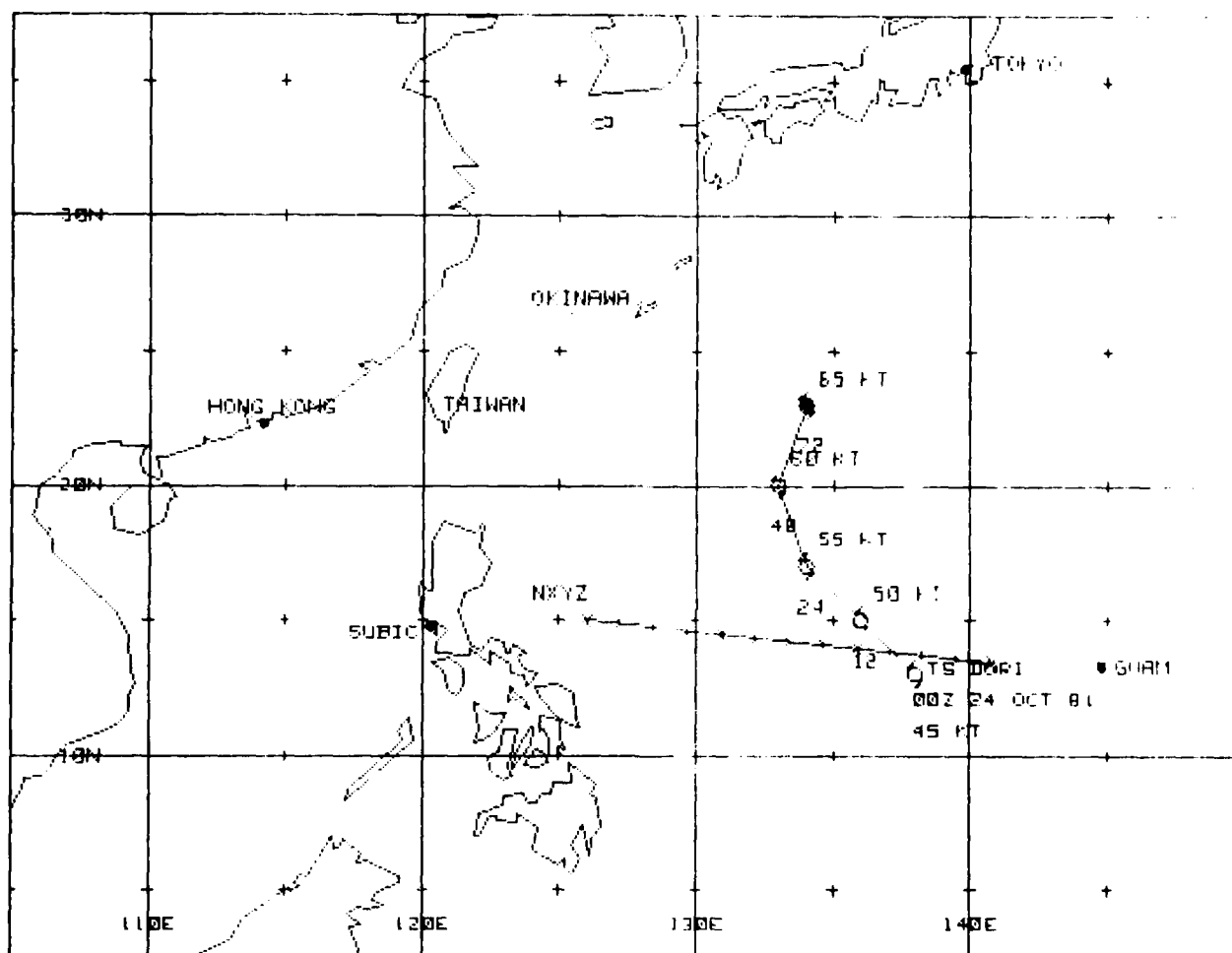


FIGURE 3-03. Example of Option 3 graphic display of the ship's projected track at six hour intervals, along with the tropical cyclone warning (Option 1).

SHIP'S ID: NONE
SHIP'S SPEED: 12 KT
DTG: 00Z 24 OCT 81

PT 1 15.0N 126.0E
PT 2 13.4N 140.8E

<u>TAU</u>	<u>LAT</u>	<u>LONG</u>
0	15.0N	126.0E
6	14.9N	127.2E
12	14.7N	128.5E
18	14.6N	129.7E
24	14.5N	130.9E
30	14.4N	132.2E
36	14.2N	133.4E
42	14.1N	134.6E
48	14.0N	135.9E
54	13.8N	137.1E
60	13.7N	138.3E
66	13.6N	139.5E
72	13.4N	140.8E

FIGURE 3-04. Example of alphanumeric listing of ship's projected track at six hour intervals (Option 3).

are exceeded, a message to this effect is provided. An alphanumeric display of the results is illustrated in Figure 3-05.

Please note that a stationary ship (speed of 0) may be used to simulate a fixed geographic location such as a port or structure for the tropical cyclone wind threat evaluation.

Option 5. Display critical probability isolines (isopleths). This option invokes Option 1 and uses the tropical cyclone warning data to calculate the critical probability isolines of 30 and/or 50 kt tropical cyclone winds at 24 hour intervals based on the warning data. An example showing the isolines for 30 and 50 kt winds superimposed on the tropical cyclone warning display is provided in Figure 3-06. The areas within the solid and dashed lines exceed the designated threshold values for the wind speeds of 30 and 50 kt, respectively, at the corresponding 24 hourly intervals.

Option 6. Automatic routing of ship. The selection of Option 6 alone, automatically invokes Options 1 and 4. This option provides the capability of calculating an alternative route if the projected ship's track, evaluated in Option 4, exceeds the critical probabilities. This alternative route may be one which proceeds along the original track but at a slower speed to allow the tropical cyclone to pass ahead of the projected ship movement, or failing this approach, attempts to circumnavigate the areas of high risk at the original average speed. The resulting route, if one can be found within the program constraints, is the shortest route which does not exceed the user designated critical values, beginning from the ship's position at the current warning date-time toward the user specified destination or secondary position during the warning period (up to 72 hours). Figure 3-07 illustrates the tropical cyclone warning (Option 1), the original ship's projected track (solid line), as a result of Option 4, and the alternative route (dashed line). Also

SHIP TRACK EVALUATION

SHIP'S ID: NXYZ

SHIP'S SPEED: 12 KT

WARNING DTG: 00Z 24 OCT 81

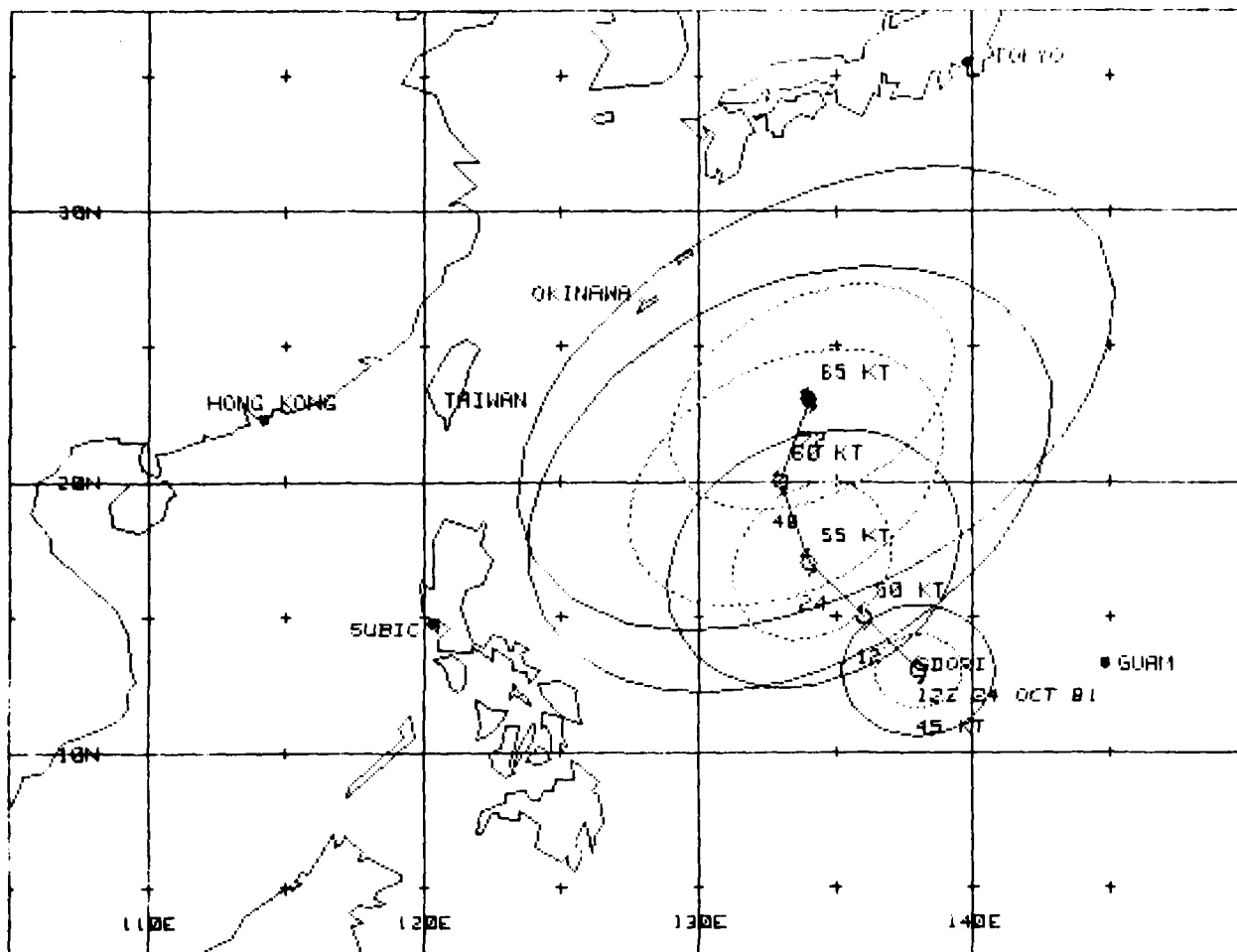
DIST: 864 NMI

TROPICAL STORM DOR1

TIME	LAT	LONG	PROBABILITIES	
			30 FT WINDS	50 FT WINDS
0	15.0N	126.0E	0.0	0.0
6	14.9N	127.2E	.0	0.0
12	14.7N	128.5E	.0	0.0
18	14.6N	129.7E	2.5	.1
24	14.5N	130.9E	9.6	1.4
30	14.4N	132.2E	12.1	2.2
36	14.2N	133.4E	9.3	1.4
42	14.1N	134.6E	6.4	.8
48	14.0N	135.9E	5.9	.8
54	13.8N	137.1E	3.2	.4
60	13.7N	138.3E	1.8	.2
66	13.6N	139.5E	1.1	.1
72	13.4N	140.8E	.5	.1

CRITICAL PROBABILITIES EXCEEDED

FIGURE 3-05. Example of Option 4 alphanumeric listing of ship evaluation showing the six hourly positions and corresponding wind probabilities.



5% PROBABILITY ISOPLETHS OF 30KT WINDS (SOLID LINES)
 3% PROBABILITY ISOPLETHS OF 50KT WINDS (DASHED LINES)

FIGURE 3-06. Example of Option 5 illustrating the instantaneous critical probability isolines (isopleths) of 30 and 50 kt tropical cyclone winds.

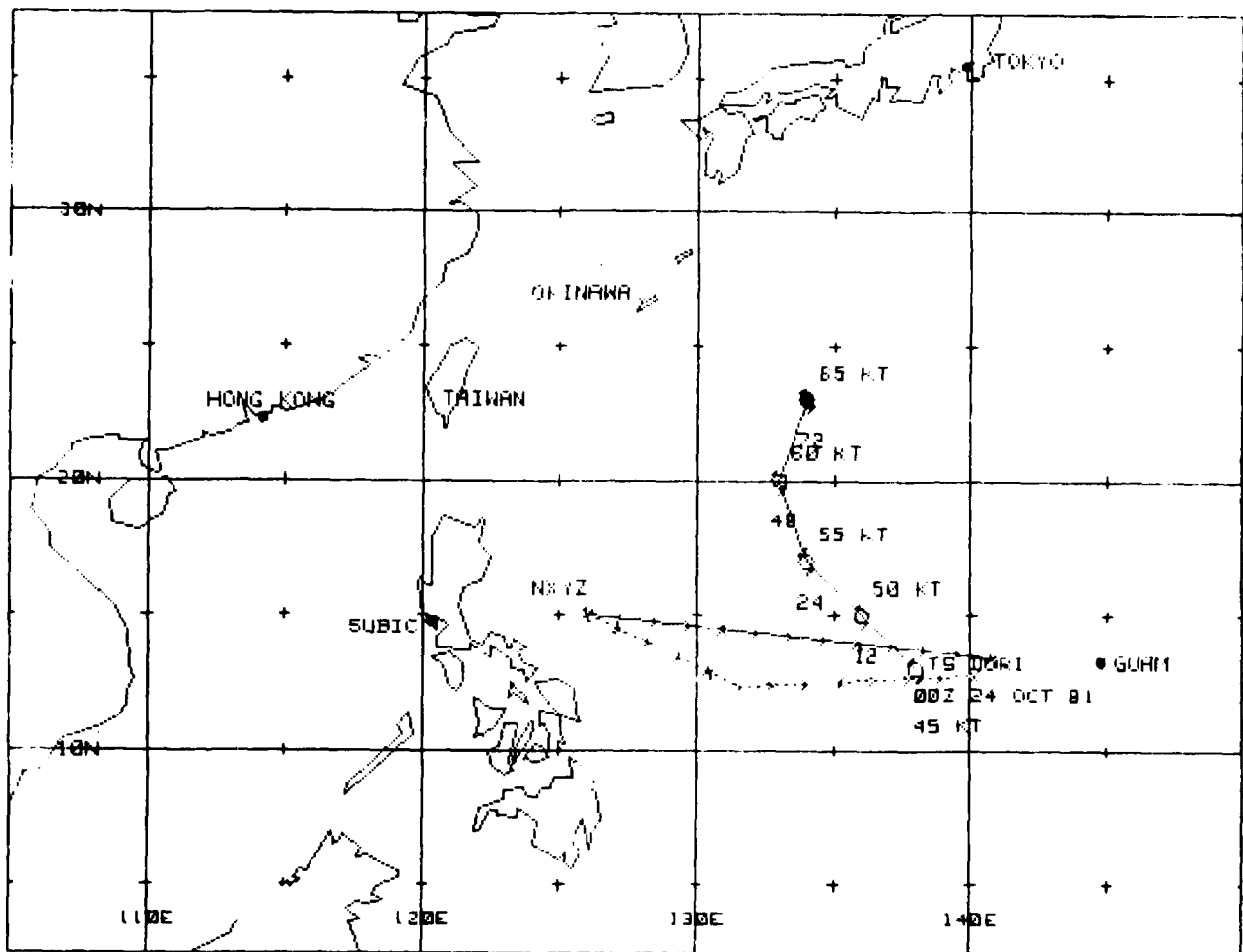


FIGURE 3-07. Example of Option 6 showing alternative route (dashed lines) as well as tropical cyclone warning and original ship's projected track (solid lines).

provided is an alphanumeric listing (shown in Figure 3-08) of the alternative route with the probabilities of 30 and 50 kt tropical cyclone winds at 6 hour intervals.

If the evaluation of the ship's projected track (Option 4) shows that the projected track is non-critical (does not exceed the critical values along the ship's track), Option 6 is cancelled.

ALTERNATE ROUTE

BEGINNING POSITION: 15.0N 126.0E

INTENDED POSITION: 13.0N 145.0E

SHIP'S ID: NXYZ

SHIP'S SPEED: 12 KT

WARNING DTG: 00Z 24 OCT 81

DIST: 864 NMI

TROPICAL STORM DORI

TIME	LAT	LONG	PROBABILITIES	
			30 KT WINDS	50 KT WINDS
0	15.0N	126.0E	0.0	0.0
6	14.5N	127.1E	.0	0.0
12	13.9N	128.2E	.0	0.0
18	13.4N	129.3E	1.4	.0
24	12.9N	130.4E	3.3	.4
30	12.4N	131.5E	3.8	.4
36	12.4N	132.8E	3.6	.4
42	12.5N	134.0E	3.1	.3
48	12.5N	135.2E	3.3	.4
54	12.6N	136.5E	2.1	.2
60	12.6N	137.7E	3	.1
66	12.7N	138.9E	8	.1
72	12.8N	140.1E	5	.1

FIGURE 3-08. Example of alphanumeric listing of alternative route provided as output of Option 6.

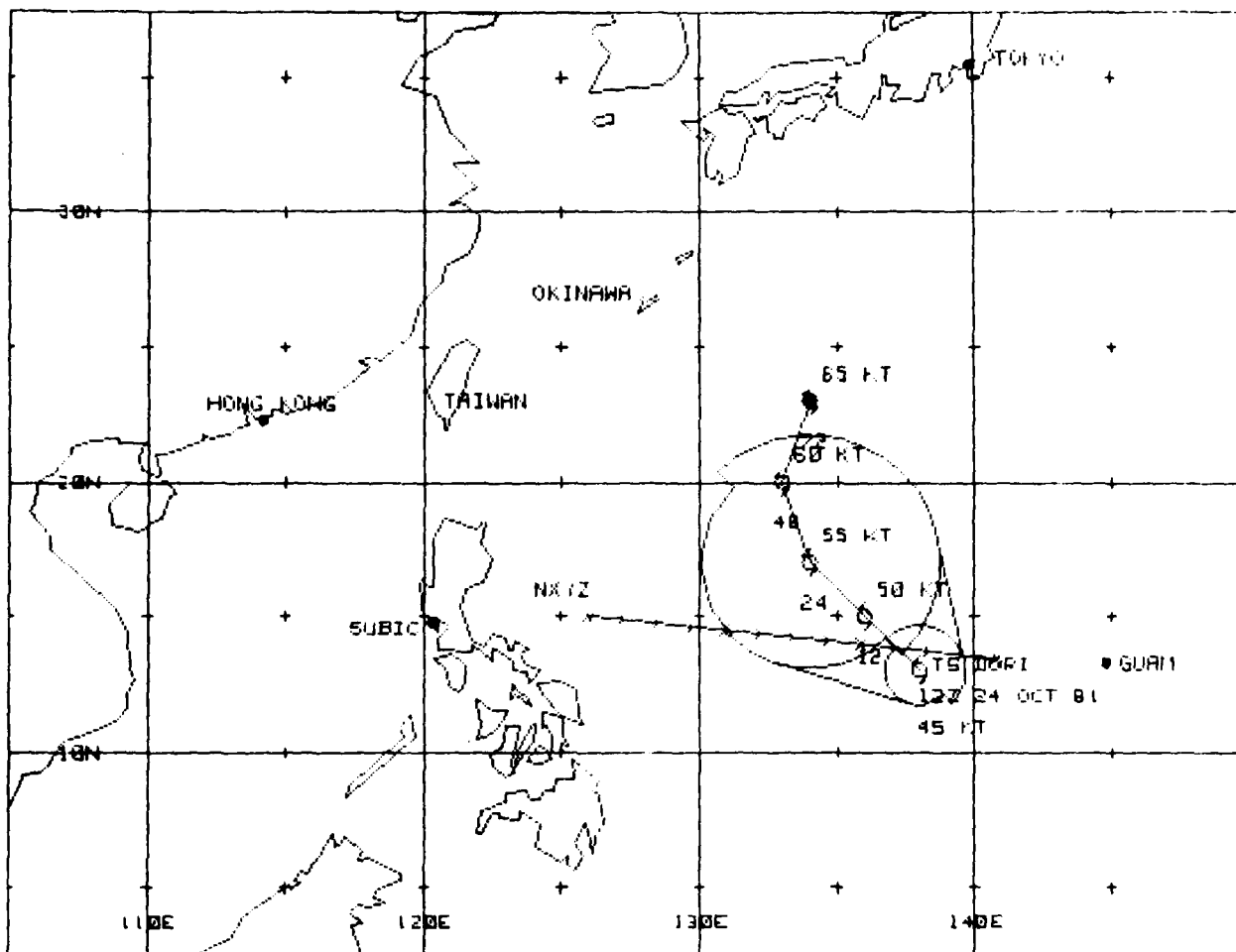
SECTION 4. APPLICATIONS

4.1 General. TCASS is a highly versatile tool which assists the shipboard user when one or more tropical cyclones pose a possible threat. Understanding of the capabilities, modes of operation and option selections allows the user to take maximum advantage of TCASS. Examples of the semi-automatic mode and other applications of TCASS are provided in this section.

4.2 Semi-automatic Mode. This mode is useful for the scenario which probably occurs most often; when only one tropical cyclone warning is in effect and the only concern of the user is a single ship route or location. The requirement for user interaction is minimized and occurs mostly at the beginning of the program. The output is fixed, with the user controlling the number of hard copies. Output examples are shown in Figures 4-01 through 4-03.

Options 1, 2, and 3 are processed initially, resulting in the graphic product shown in Figure 4-01. This product shows the tropical cyclone warning for a tropical storm in graphic and alphanumeric form, the "danger" area, and the ship's projected track. In this example, ship NXYZ is proceeding from a position east of Luzon, Philippine Islands toward Guam. Because no wind probability calculations are required thus far, the whole process takes approximately 3 minutes exclusive of data entry time, with tape reading processes and plotting of the map background consuming most of this time.

Options 3, 4, and 5 are then performed. The ship track evaluation is displayed in alphanumeric form and the user specified critical probability isopleths of 30 kt winds plotted, along with the tropical cyclone warning and ship's projected track (Figure 4-02). In this example, the projected



WARNING DTG: 12Z 24 OCT 81

TROPICAL STORM DORI WARNING NR 4 DIR SPD 310 DEGREES 9 KTS

00 HR INITIAL POSITION 1300N 13800E MAX WIND 45 KT

RADIUS OF 30 KT WINDS 100 MILES NE SEMICIRCLE, 75 MILES ELSEWHERE

12 HR FORECAST POSITION 1500N 13600E MAX WIND 50 KT

24 HR FORECAST POSITION 1700N 13400E MAX WIND 55 KT

RADIUS OF 50 KT WINDS 30 MILES

RADIUS OF 30 KT WINDS 150 MILES NE SEMICIRCLE, 100 MILES ELSEWHERE

48 HR FORECAST POSITION 2000N 13300E MAX WIND 60 KT

RADIUS OF 50 KT WINDS 50 MILES

72 HR FORECAST POSITION 2300N 13400E MAX WIND 65 KT

RADIUS OF 50 KT WINDS 75 MILES

FIGURE 4-01. Example of output as a result of Options 1, 2, and 3 in the semi-automatic mode.

SHIP TRACK EVALUATION

SHIP S ID: N072

SHIP S SPEED: 12 KT

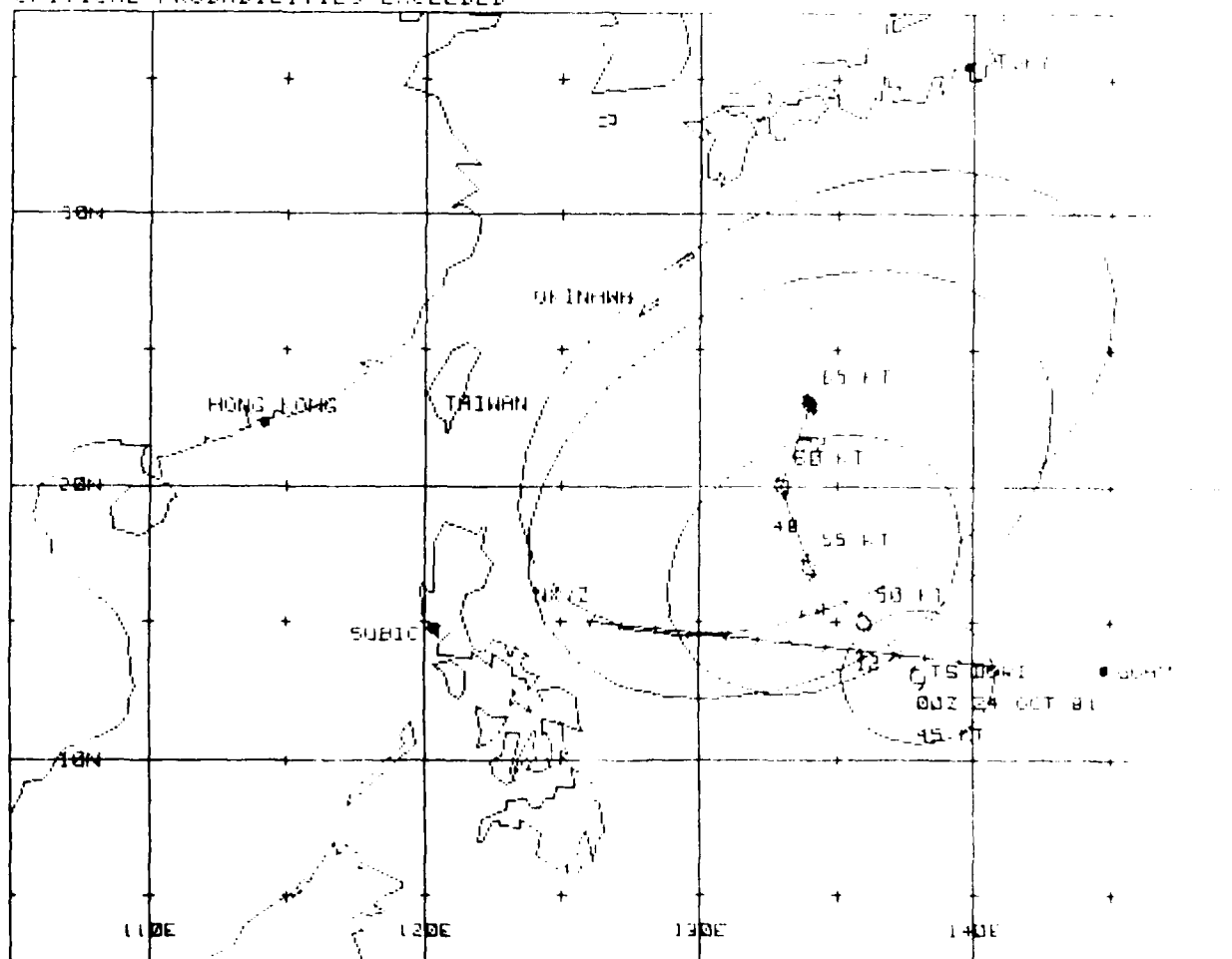
WARNING DTG: 00Z 24 OCT 81

DIST: 864 NM

TROPICAL STORM D081

TIME	LAT	LONG	PROBABILITIES	
			30 KT WINDS	50 KT WINDS
0	15.0N	126.0E	0.0	0.0
6	14.9N	127.2E	.0	0.0
12	14.7N	128.5E	.0	0.0
18	14.6N	129.7E	2.5	.1
24	14.5N	130.9E	9.6	1.4
30	14.4N	132.2E	12.1	2.2
36	14.2N	133.4E	9.3	1.4
42	14.1N	134.6E	6.4	.8
48	14.0N	135.9E	5.9	.8
54	13.8N	137.1E	3.2	.4
60	13.7N	138.3E	1.8	.2
66	13.6N	139.5E	1.1	.1
72	13.4N	140.8E	.5	.1

CRITICAL PROBABILITIES EXCEEDED



51. PROBABILITY ISOPLETHS OF 30KT WIND: (SOLID LINES)

FIGURE 4-02. Example of output provided by Options 4 and 5 in the semi-automatic mode.

ALTERNATE ROUTE
 BEGINNING POSITION: 15.0N 126.0E
 INTENDED POSITION: 13.0N 145.0E

SHIP'S ID: NXYZ
 SHIP'S SPEED: 12 KT
 WARNING DTG: 12Z 24 OCT 81

DIST: 864 NMI
 TROPICAL STORM DORI

TIME	LAT	LONG	PROBABILITIES	
			30 KT WINDS	50 FT WINDS
0	15.0N	126.0E	0.0	0.0
6	14.5N	127.1E	.0	0.0
12	13.9N	128.2E	.0	0.0
18	13.4N	129.3E	1.4	.0
24	12.9N	130.4E	3.3	.4
30	12.4N	131.5E	3.8	.4
36	12.4N	132.8E	3.6	.4
42	12.5N	134.0E	3.1	.3
48	12.5N	135.2E	3.3	.4
54	12.6N	136.5E	2.1	.2
60	12.6N	137.7E	1.3	.1
66	12.7N	138.9E	.8	.1
72	12.8N	140.1E	.5	.1

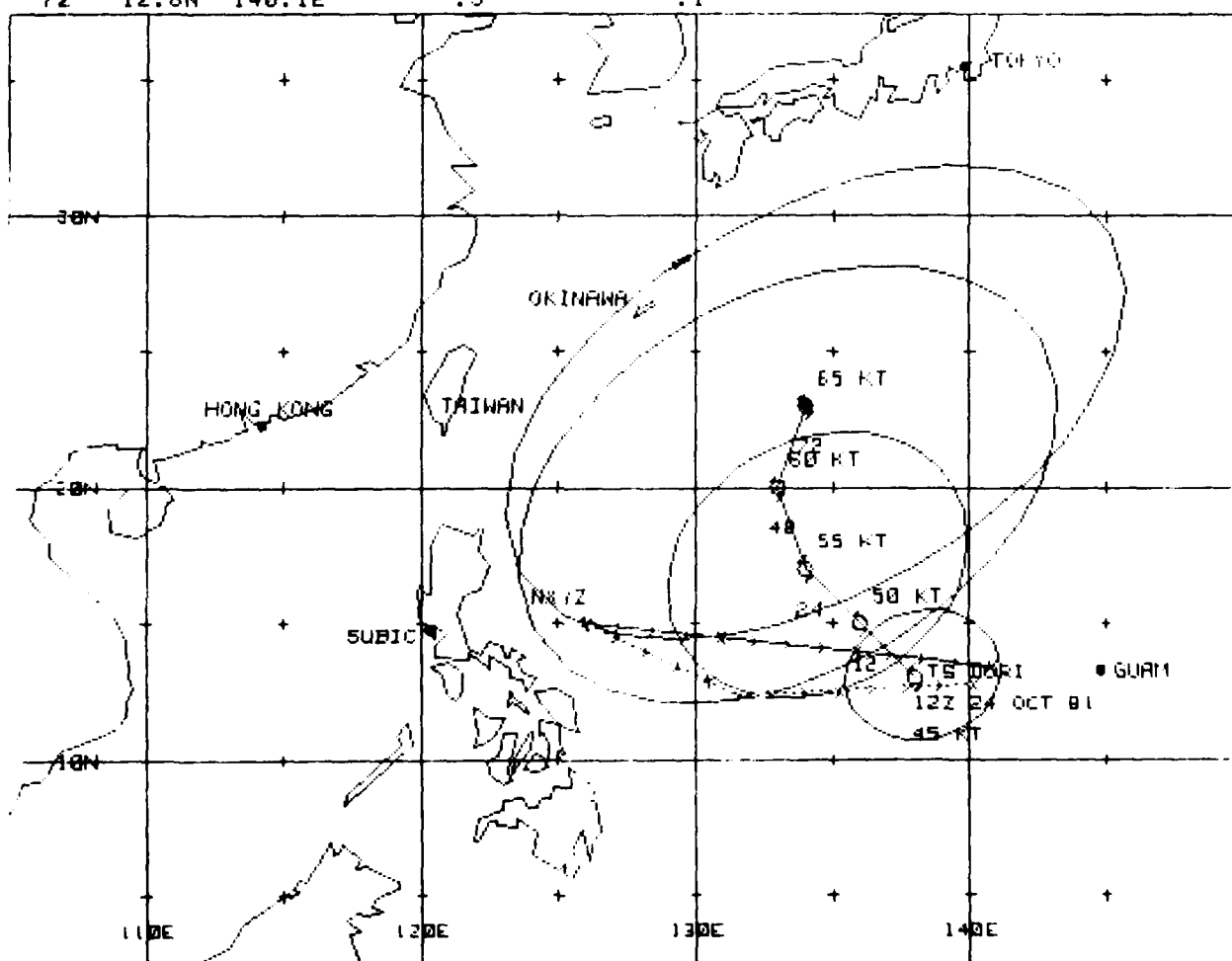


FIGURE 4-03. Example of output produced by Option 6 in the semi-automatic mode.

ship's track exceeds the critical values; alternative routing is invoked. The user specifies the ship's destination or secondary position toward which the routing is desired and the program proceeds with the alternative routing. The resulting route is listed in alphanumeric form and the alternate route plotted as a dashed line on the same display as above. The resulting product is illustrated in Figure 4-03.

Processing of Option 4 takes 1½-2 minutes. Option 5 requires from 5 to 9 minutes depending on whether the 30 or 50 kt isopleths are selected or both, and the duration of the warning. Option 6 expends another 1-2 minutes if invoked.

4.3 Other Applications. Figures 4-04 through 4-10 show additional TCASS applications. A description of each example accompanies the illustration.

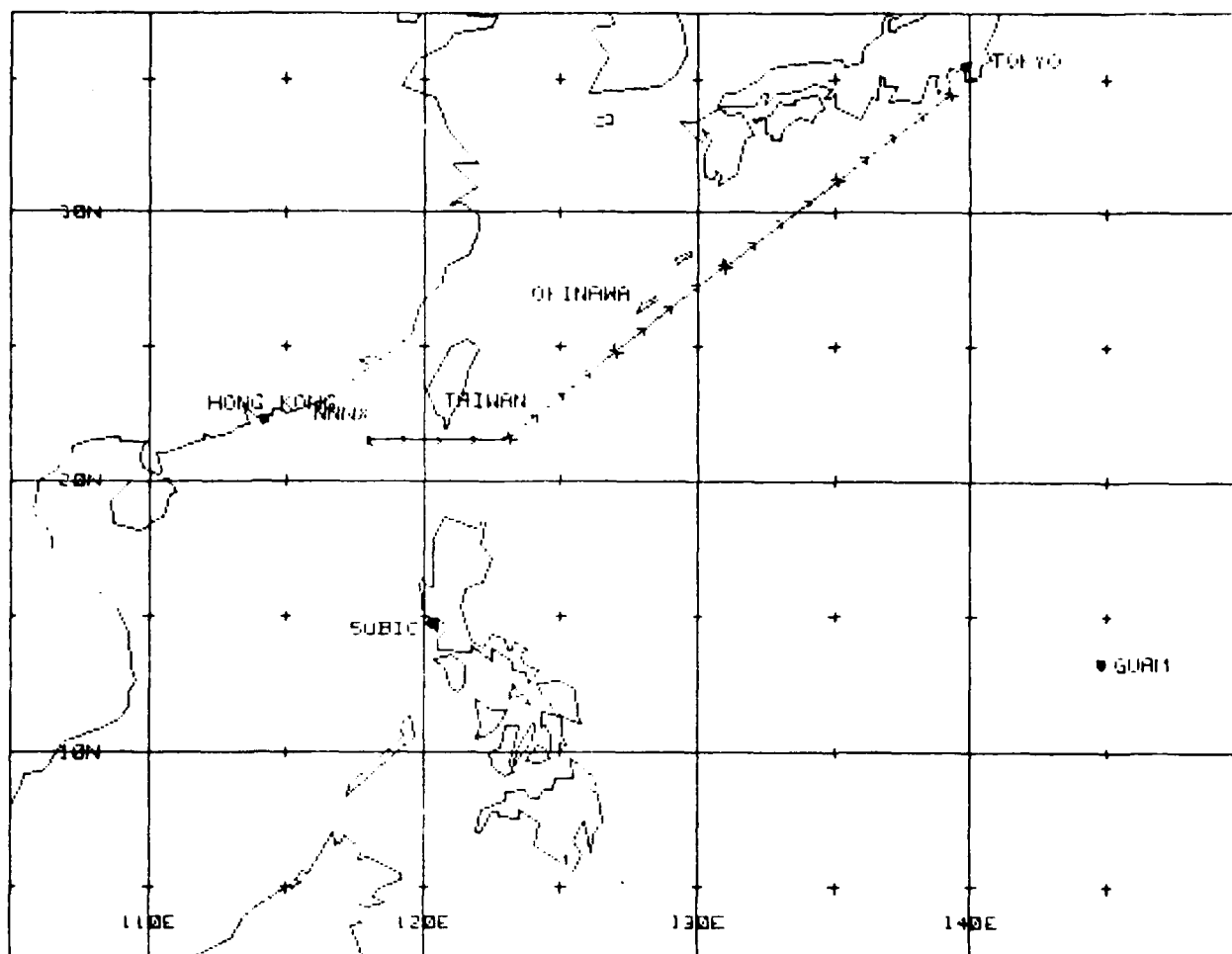


FIGURE 4-04. This example shows a use of TCASS for briefing and display purpose only, with no TC warnings in effect. The 120 hour track for ship "NNNX" enroute to Yokosuka, Japan at 15 kts is depicted. This was produced in the selective mode, with Option 3. The ship was plotted as 2 ships. The first from the vicinity of Hong Kong to a point southeast of Taiwan, and then northeastward toward Yokosuka. The route was continued by plotting a second ship with a call sign of "bbbb" (4 blanks in quotes) from the 48 hour position toward Yokosuka for another 72 hours.

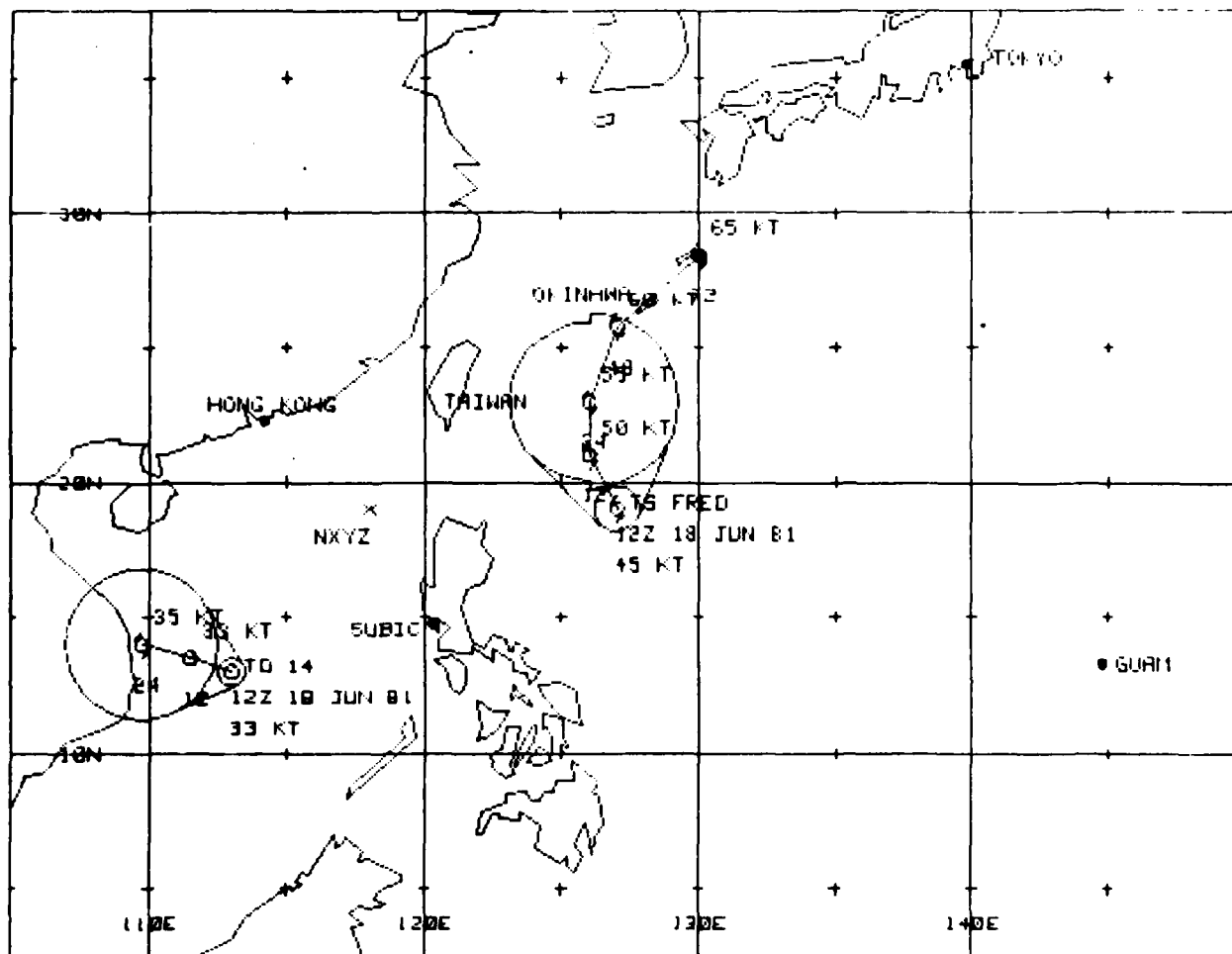


FIGURE 4-05. This display illustrates an example of ship "NXYZ" operating in the vicinity of 19°00'N, 118°00'E with two tropical cyclone warnings in effect (TD14 and tropical storm FRED). The "danger" areas for the respective tropical cyclones are shown. This example, obtained in the selective mode using Options 1, 2, and 3, is appropriate for qualitative evaluation and briefing purposes.

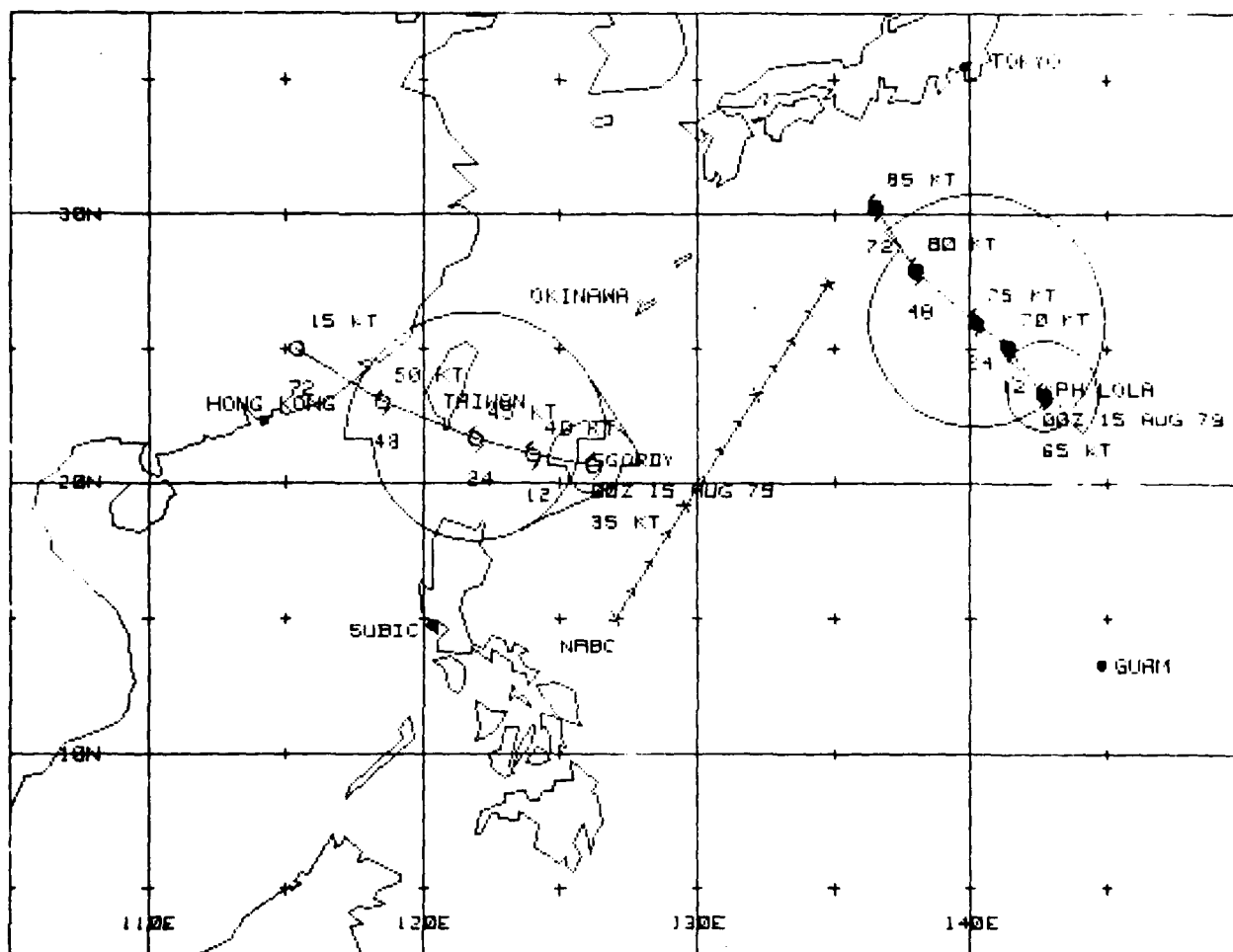


FIGURE 4-06. In this example, Options 1, 2, and 3 were selected to produce this product. Ship "NABC" is enroute from an area east of Luzon Island toward Tokyo at 12 kt. Tropical storm Gordy and Typhoon Lola pose possible threats. The close proximity of the ship to Typhoon Lola at 72 hours after the warning time suggests a high level of threat. Tropical storm Gordy indicates a minimum threat. Selection of the other options of TCASS provides the capability of reinforcing the subjective evaluation.

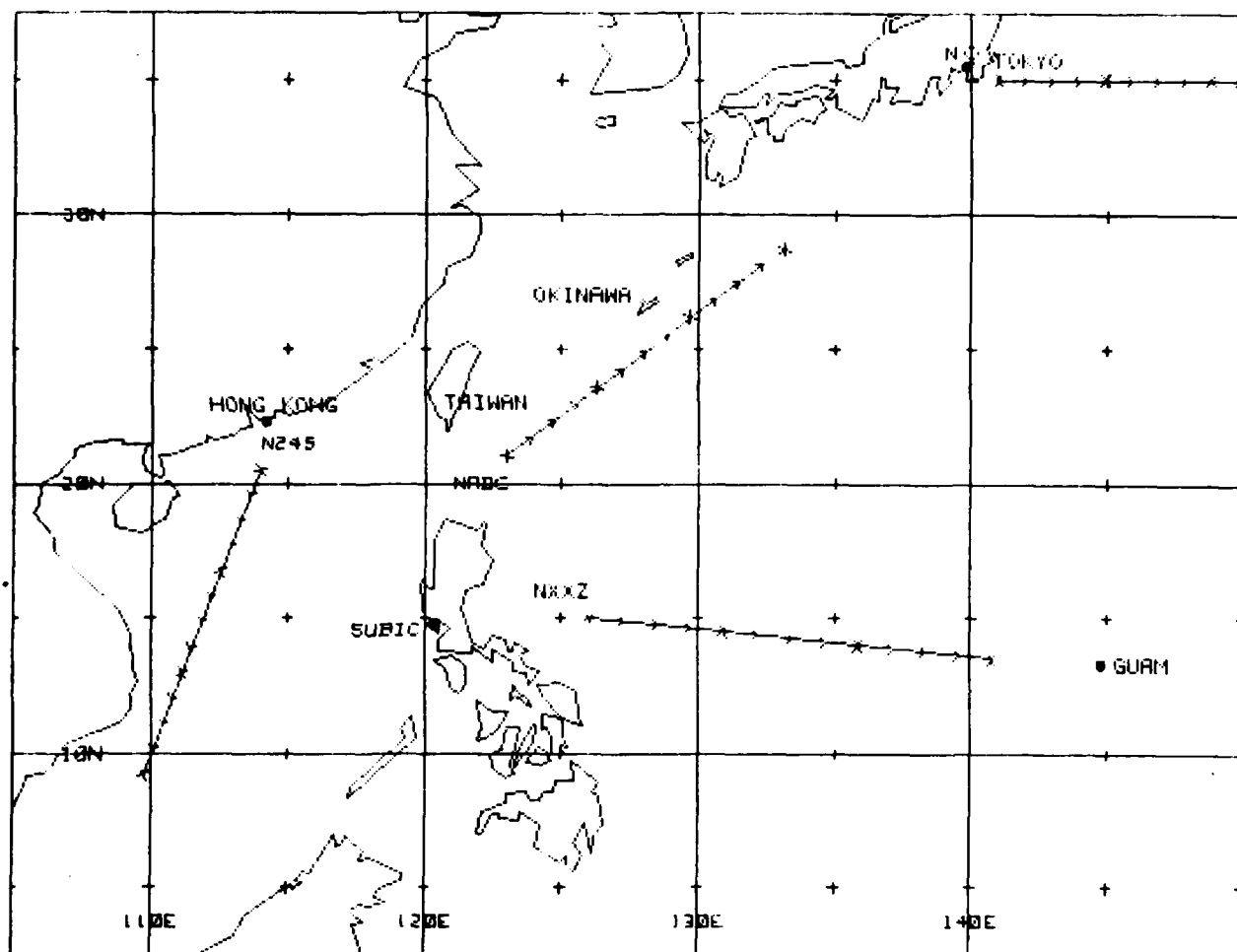


FIGURE 4-07. Example of the use of Option 3 in the selective mode for displaying the projected tracks of several ships for briefing purposes when no warnings are in effect.

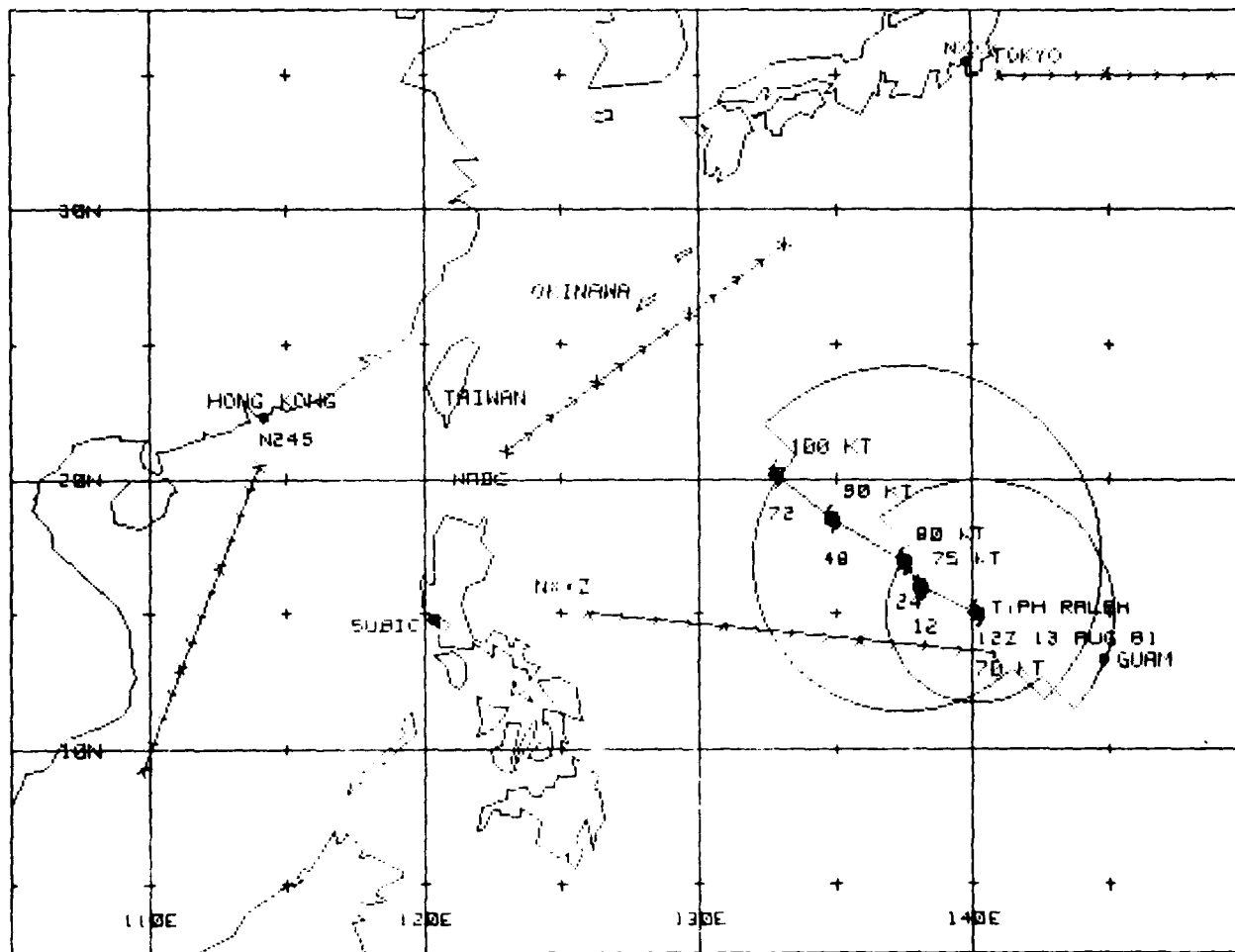
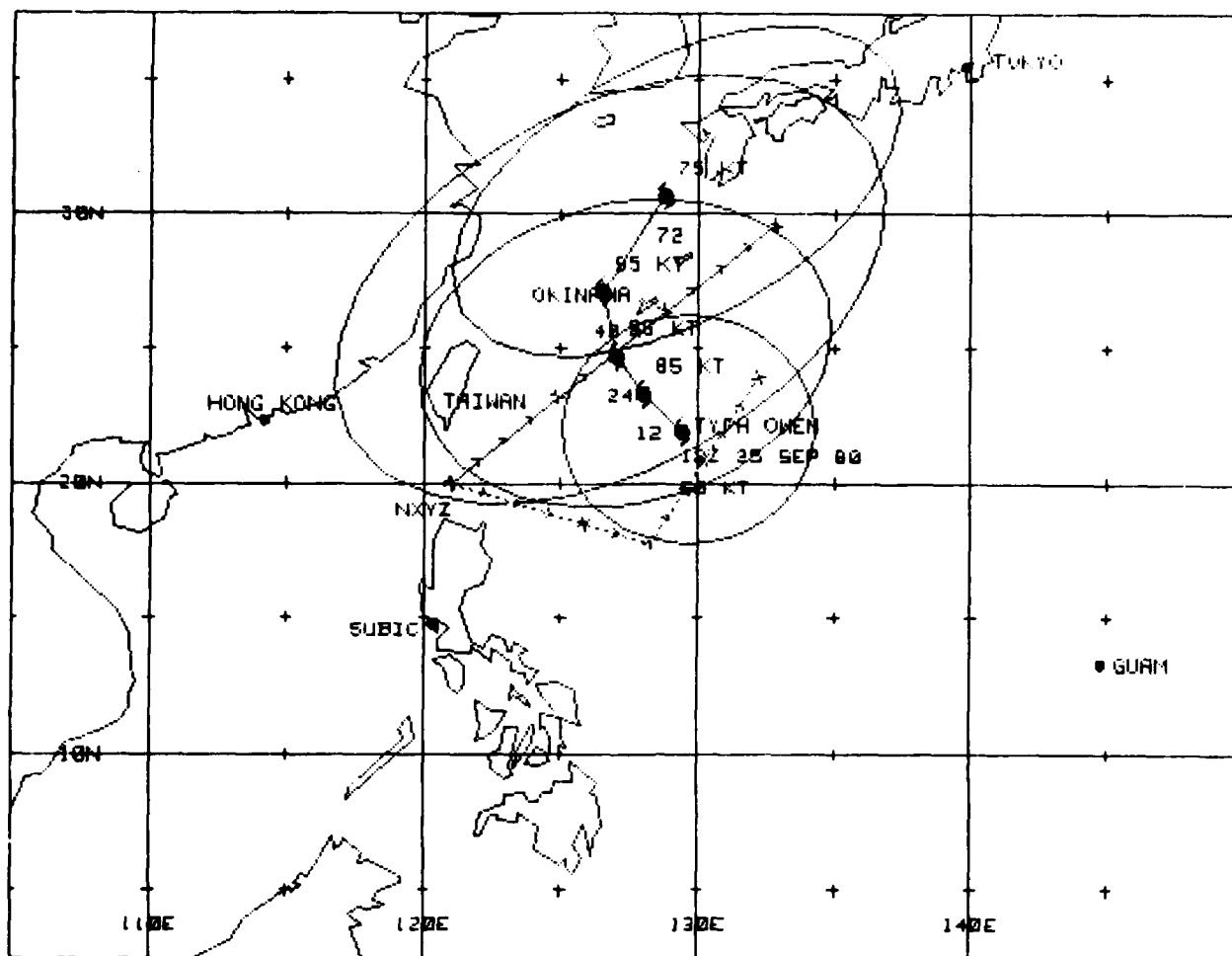
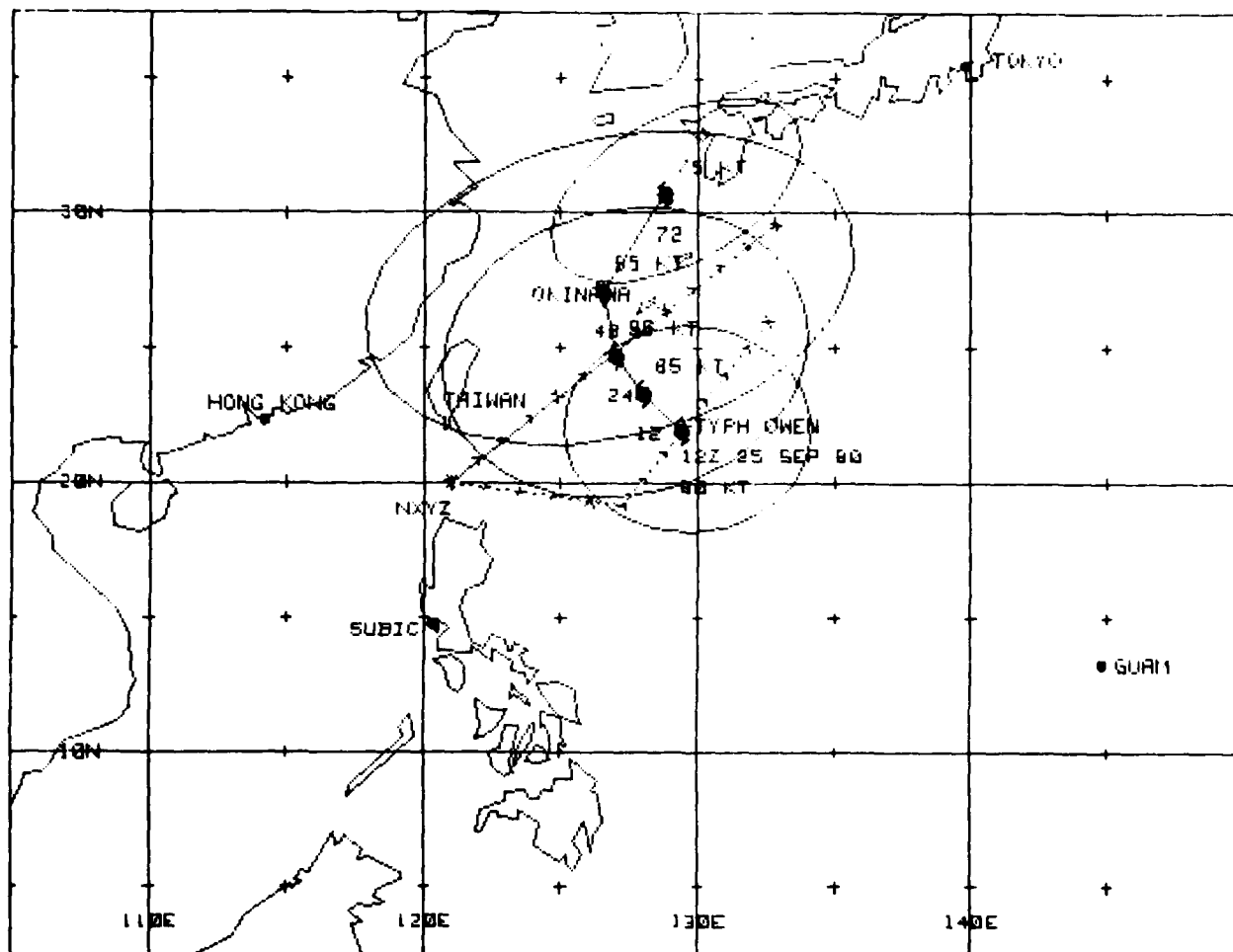


FIGURE 4-08. Similar to Figure 4-07 with a typhoon warning in effect and showing the "danger" area of 30 kt winds (produced using Options 1, 2, and 3 in the selective mode).



5% PROBABILITY ISOPLETHS OF 30KT WINDS (SOLID LINES)

FIGURE 4-09. Example of alternative routing of ship "NXYZ" transiting the Bashi Channel toward Tokyo and threatened by typhoon Owen. The critical probability of 30 kt winds was set at 5% and only the critical probability isopleths of 30 kt winds were desired. This example is a result of Options 4, 5, and 6 in the selective mode.



10% PROBABILITY ISOPLETHS OF 30KT WINDS (SOLID LINES)

FIGURE 4-10. Same as Figure 4-09, except the critical probability of 30 kt winds was set at 10%. Note the relatively smaller area covered by the isopleths, and the less divergent alternative route.

SECTION 5. LIMITATIONS AND RECOMMENDATIONS

5.1 Limitations. The limitations of the initial version of TCASS are summarized as follows:

- a. The application of the initial version of TCASS is restricted to the western North Pacific Ocean. The plot area is further limited to the geographical map background described in subsection 2.2.
- b. The map background is not a true mercator projection and some distortion is present. However, the latitude/longitude calculations of the tropical cyclone positions and ship tracks are accurately represented.
- c. There are no land-sea discrimination capabilities in the ship track and alternative routing processing.
- d. The wind probability calculations are restricted to tropical cyclone winds only and do not infer any winds from the existing large scale synoptic situation, such as the tightening of the gradient between the subtropical ridge and the tropical cyclone or the influence of local topography as the tropical cyclone approaches land.
- e. Sea and swell conditions are important factors to consider in tropical cyclone threat situations but are not incorporated into the current version of TCASS.
- f. The wind probabilities calculated within TCASS are instantaneous probabilities of encountering 30 and 50 kt tropical cyclone winds at 6 hour intervals. Time integrated (cumulative) probabilities are not directly available.
- g. Past history of the tropical cyclone warning positions is not saved for display.

5.2 Recommendations. The elimination of some of the above limitations are recommended in developing improvements to TCASS. A trade off between program size (and execution time) and the benefits derived must be considered in any enhancements to TCASS.

Applications to other geographical areas are currently undergoing development. TCASS versions for the North Atlantic Ocean, eastern North Pacific Ocean, and Indian Ocean are expected to be available within the near future. Inclusion of a true mercator background and the addition of past history are suggested as practical improvements. Overcoming the other limitations do not appear to be advantageous at this time.

Additional research and development efforts are needed before sea and swell information may be provided as a part of TCASS.

SECTION 6. REFERENCES

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4. Systems and Applied Sciences Corporation, July 1981: Tropical Cyclone Applications Software System (TCASS) Users Manual - Western North Pacific Ocean. Naval Environmental Prediction Research Facility Shipboard Numerical Aids Program (SNAP) No. 7.

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