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Elements of Tropical Cyclones Avoidance Procedure

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ABSTRACT: The updated version of the Cyclone II program was used for analyzing hundreds of cases where ships were facing dozens of developed cyclones. The program generates directions for navigators that are recommended for consideration before making decisions on passing around or avoiding tropical cyclones. Three specific situations were defined where a vessel may enter the area affected by a tropical cyclone, and its commander must consider three recommendations for safe passing of the cyclone:
– vessel – cyclone encounter, where if on opposite course, the most effective is course alteration;
– when the ship overtakes the cyclone, speed reduction is the most effective action;
– when the vessel and the cyclone are on crossing routes (30 ÷ 90°), a slight decrease in speed or a slight course alteration or both actions can be effective.

1 INTRODUCTION

In areas where tropical cyclones occur navigators must apply the procedure for obtaining information and the identification of the danger on the expected track of the vessel, the accuracy in determining the sectors safe and unsafe, taking into account velocity vectors of the ship (Vs) and the cyclone (Vc). As a result, we decide how to most effectively avoid the area threatened by a tropical cyclone [1-5].

The means for using the procedure include a computer program developed by these authors, described in previous publications [6]. Among others, the software takes into account the procedure for programming the route of the vessel at the time of receiving the message about the cyclone for the following hours and days, with forecasts of expected cyclone positions, and predicted by calculations future positions of the ship.

2 PROCEDURES AND METHODOLOGY

One may find that being together with the cyclone vessel is possible in three specific situations:

- vessel and cyclone move in opposite directions (ahead or nearly ahead of the ship);
- vessel catches up with the cyclone on a similar course;
- projected route of the ship crosses the projected path of the cyclone (eye of the cyclone track) at an angle of (30° ÷ 90°) and the moment when the ship will enter the waters on tropical cyclone threat.

For these three variants examples were tested, based on real data on cyclones in the years 2008 - 2010 and for the actual and random positions of selected ships owned by the Polish Steamship Company (PSC). Typically, for one cyclone four vessels in positions spaced symmetrically around the cyclone were chosen, that is, from the point of dangerous winds ≥ 34 kn. The moment of decision-making was the situation when calculations showed the entry of the vessel in a dangerous sector of the cyclone in less than 48 hours (TCPA)

The test results will be illustrated by a situation, where the cyclone Bill was being avoided from 20 to 23 August 2009. The cyclone moved along a parabolic trajectory across the North Atlantic. Part of the first message of 20 Aug 2009 is shown in Table 1.

Table 1. Fragment of a message printout: cyclone BILL on 20/08//2009

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ZCZC MIATCMAT3 ALL
TTAA00 KNHC DDHHMM CCA
HURRICANE BILL FORECAST/ADVISORY NUMBER
21...CORRECTED
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL
AL032009
1500 UTC THU AUG 20 2009

REPEAT...CENTER LOCATED NEAR 22.6N 61.7W AT
20/1500Z
AT 20/1200Z CENTER WAS LOCATED NEAR 22.1N
61.0W

FORECAST VALID 21/0000Z 24.2N 63.8W
MAX WIND 110 KT...GUSTS 135 KT.
64 KT... 90NE 45SE 30SW 75NW.
50 KT...120NE 90SE 60SW 100NW.
34 KT...225NE 200SE 100SW 200NW.

FORECAST VALID 21/1200Z 26.6N 66.0W
MAX WIND 115 KT...GUSTS 140 KT.
64 KT... 75NE 45SE 30SW 45NW.
50 KT...120NE 100SE 70SW 100NW.
34 KT...225NE 200SE 120SW 180NW.

FORECAST VALID 22/0000Z 29.5N 67.5W
MAX WIND 115 KT...GUSTS 140 KT.
64 KT... 75NE 45SE 30SW 45NW.
50 KT...120NE 100SE 70SW 100NW.
34 KT...225NE 200SE 120SW 180NW.

FORECAST VALID 22/1200Z 32.5N 69.0W
MAX WIND 110 KT...GUSTS 135 KT.
50 KT...120NE 100SE 70SW 100NW.
34 KT...225NE 200SE 120SW 180NW.

FORECAST VALID 23/1200Z 40.5N 66.5W
MAX WIND 100 KT...GUSTS 120 KT.
50 KT...120NE 120SE 70SW 100NW.
34 KT...225NE 225SE 120SW 180NW.
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Four ship positions for 12.00 (20.08.2009)

- a ship at the port road of New York travelling to Brazil,
- vessel B in the position φ = 15.07°N, λ =059.9°W on the way to N. York,
- ship in the Mona Passage φ = 18.04°N, λ =074.98°W on the way to Europe,
- ship in the actual position D φ = 40°N, λ = 040°W on the way to N. York,
- and the position of the cyclone φc = 22.1°N, λ = 061°W at the same time and day.

In connection with weather forecasts for the next 12, 24, 36, 48, and 72 hours, cyclone positions were taken from messages and then future ship's positions were calculated.

3 RESULTS

For ship (A) departing from New York after receiving a message about the cyclone, data were entered to the computing program "Cyclone II ":

- their position, intended course (course over ground = 15°) to Brazil, and the estimated speed of 13,
- data on the location of the cyclone, its course and speed (vertical panel) - Fig.1.,
- data on forecasts of the cyclone 12, 24, 36, 48, 72 hours (horizontal panel) - Fig.1.

The calculation results indicate that the ship proceeds to a dangerous course sector 149° - 197°, 1254.7 Nm from the eye of the cyclone, and after 43.7 hours (TCPA) it will reach the closest point approach 234Nm (CPA). By obtaining the cyclone position from 72 hour forecast illustrating the predicted cyclone movement path, the captain chooses a new ship's course (COG = 180°) and decides to check what the vessel and cyclone positions will be in 12, 24, 36, 48 and 72 hours. Figure 2 illustrates the results of calculations and relative ship – cyclone positions after 24 hours. The ship passes the cyclone after 48 hours and alters the new COG = 130° to return on route to Brazil, being safe on this course at a distance of 328.4 Nm from cyclone eye (Fig. 3). Finally, the ship extends its distance covered by 210Nm, maintaining a speed of 13.2 kn, i.e. and will prolong the voyage by 16 hours to pass by the cyclone.

For ship (B) in position: 51.07°N, 059.9°W on the way to New York (COG = 230°, Vs = 23kn) it is estimated that it is on a dangerous course (308 ÷ 343°) and after 37.8 hours will be at the closest point approach, i.e. 129.2 Nm from the cyclone influence, affected by winds ≥ 34 knots (Fig. 4). The ship has to reduce its speed below 19.1 kn.

To avoid entry into the cyclone-affected area, the vessel loses 72Nm (3 x 24), which means proceeding at a speed of 19.1kn. This prolongs the expected time of voyage by about 3 hrs 40 min.

Ship (C), sailing in the Mona Passage on its way to Europe, performs testing to pass by the cyclone Bill for the same times on 20.08.2009. The information obtained is that it is on the boundary of dangerous sector (331° to 55°) remaining on course COG = 055° and sailing at a speed of 13 knots (results in the vertical panel - Figure 5). By introducing cyclone data forecast to the program Cyclone II for up to 72 hours, the ship commander finds out that continuing the trip at a speed Vs = 13.0kn, after 12 hours (Fig. 6) its COG = 055°, while the ship will get into a safe sector reaching the closest point of approach 333.4 Nm from the cyclone eye. For this situation no changes of speed and course relative to the cyclone Bill are needed, therefore neither distance not voyage time will be extended.

On 20.08.2009. at 12.00UTC ship (D) is very far from the cyclone, in position φ = 40°N, λ = 039.15°W and on course COG = 270° on the way to New York. From entered forecast data and expected vessel positions (Vs = 13.0kn), only simulation (testing) for 48 hours shows that ship's course will approach the dangerous sector (272°-358°), then sailing at a distance of 907.16 Nm from the cyclone eye (Fig. 7). A simulated situation for passing the cyclone Bill is shown in Figure 7, 8 and 9 for August 22nd 2009. The ship, sailing one day on course COG = 230° and then returning to the course COG = 288° leading to New York, extended the original rhumbline route by about 104 Nm only, corresponding to a prolonged travel time of 8 hours. The ship made a successful maneuver, passing the cyclone at a distance of 338Nm from the outer cyclone dangerous area, where wave heights were 4.0m ≥ m. Performing simulations of the cyclone and ship position projections for the next 72 hours, we get a positive result confirming cyclone avoidance.

4 CONCLUSIONS

1 For the vessel and the cyclone collision situation on opposite courses (ship A) the course alteration is the most effective. The reduction of speed only did not give a positive result for a speed of cyclone movement Vc ≥ 10kn.
2 For the situation when the ship overtakes the cyclone, the most effective is ship's speed reduction relative to cyclone movement, because the track will not be prolonged, and is fuel consumption is likely to be lower (ship B).
3 A special case is where a vessel expects that its planned route will cross the cyclone path, but without the entry of the vessel into the cyclone affected area, and it does not alter change speed or course (vessel C).

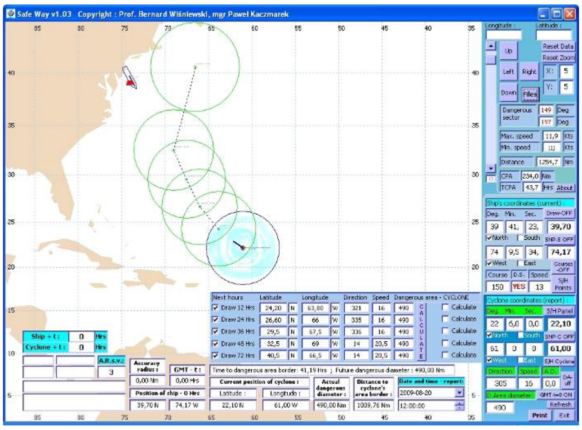

Figure 1 Graphic illustration of the cyclone path, based on weather report and calculations for ship A, heading for Brazil (20-08-2009, 12.00UTC).

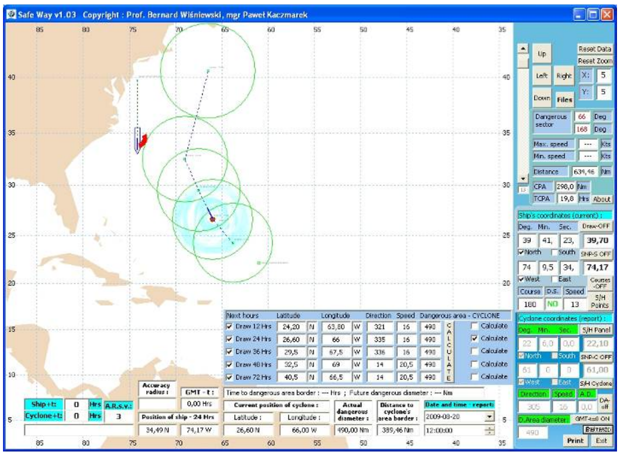

Figure 2 Graphic picture of cyclone and ship A positions, after 24 hour travelling time, and calculation results.

4 With the projected route of the vessel and the cyclone path are likely to cross each other (30 ÷ 90°), and when the probability of vessel entry into the area of cyclone influence, slight ship's speed decrease or small course alteration (ΔCOG ≤ 40°) can be effective, as illustrated by the case of ship D, or both changes mentioned above may be made.

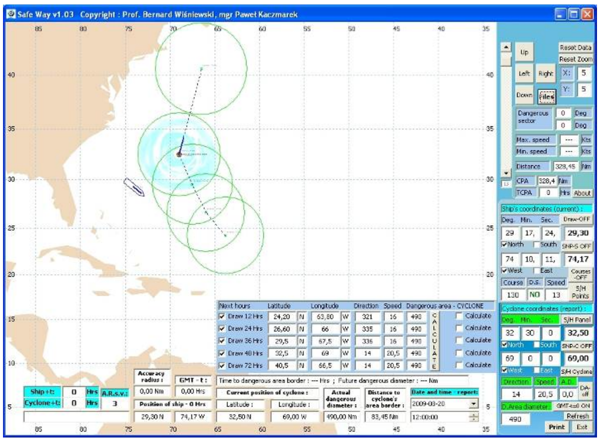

Figure 3 Graphic picture of ship A and cyclone positions after 48 hours in relation to course alteration to 130 degrees.

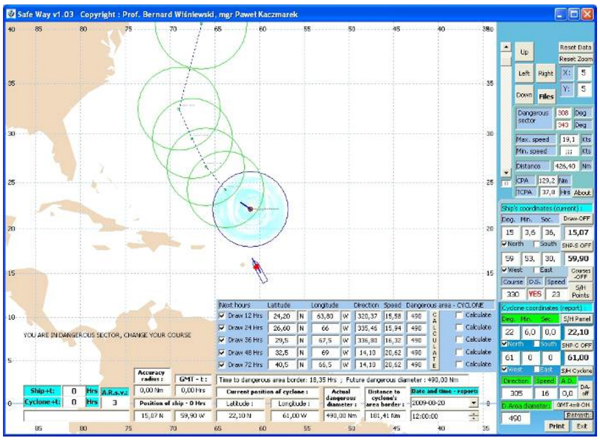

Figure 4 Graphic picture of cyclone track according to received data and calculations for ship B, heading for New York (20-08-2009, 1200 UTC).

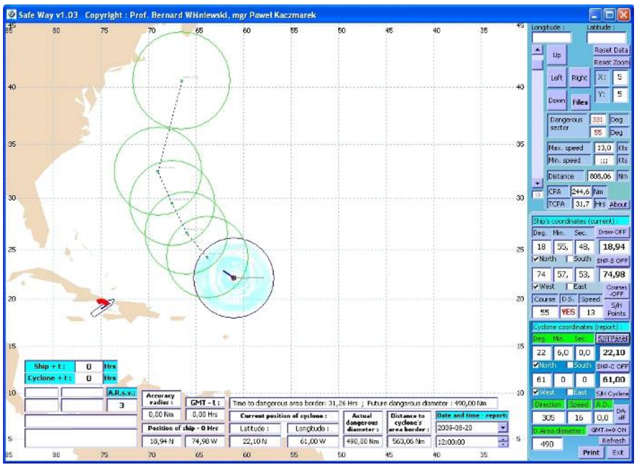

Figure 5 Graphic picture of cyclone track according to received data and calculation results for ship C, Mona Passage, ship proceeding to Europe (20-08-2009, 1200 UTC).

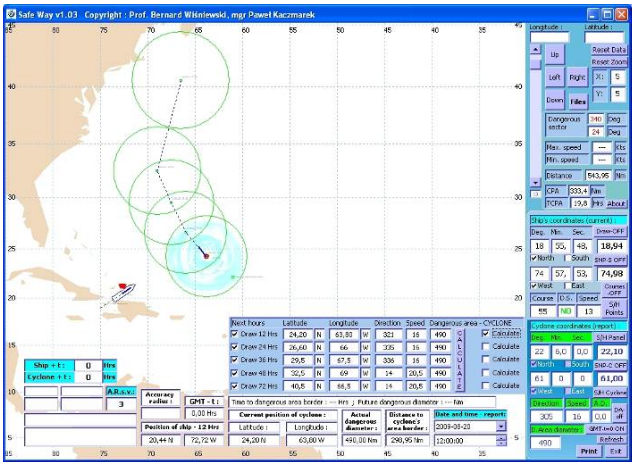

Figure 6 Graphic picture of cyclone and ship C positions during the voyage and calculation results.

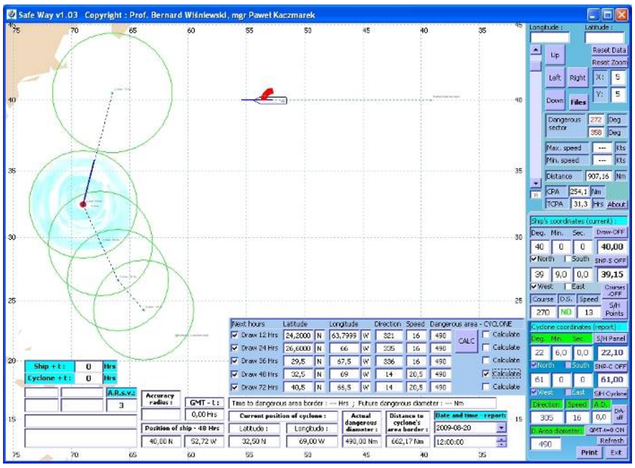

Figure 7 Graphic results of cyclone track according to message and calculation results for ship D after 48 travel hours from 20-08-2009, at. 1200 UTC.

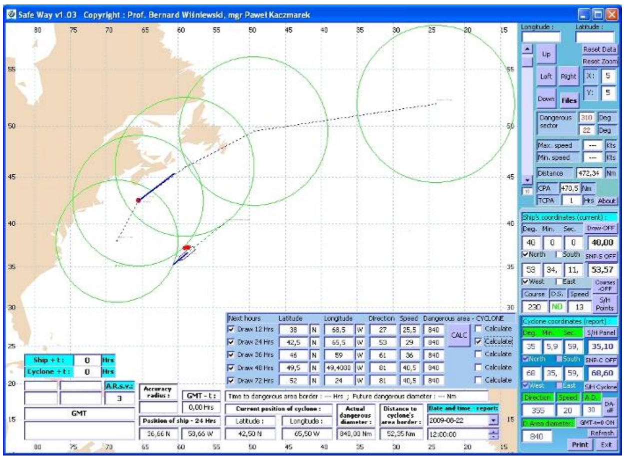

Figure 8 Graphic picture of cyclone and ship D positions according to the message on 22-08-2009, after altering course.

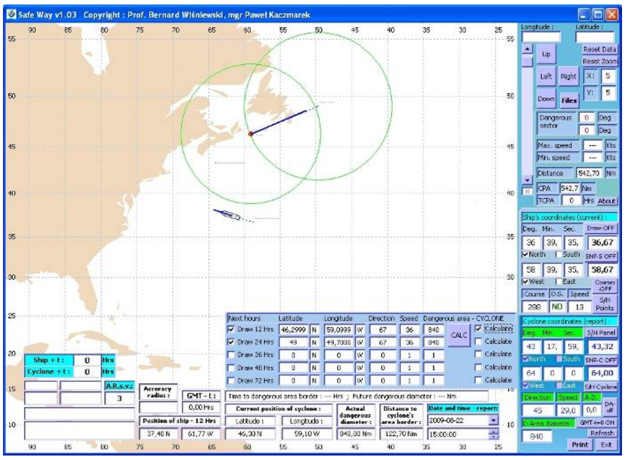

Figure 9 Graphic picture of cyclone and ship D positions after 12 hours after altering course to 288 degrees, voyage to to New York.

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