

The analysis of possibilities how the collision between m/v 'Gdynia' and m/v 'Fu Shan Hai' could have been avoided

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ABSTRACT: The report presents the simulation results of collision between m/v “Gdynia” and m/v “Fu Shan Hai”. The analysis was performed by means of decision support in collision situations. This system is based on a structure of programme multiagents using AIS data (Automatic Identification System) with the possibility of cooperation between agents or vessels. The multiagent system of supporting anticollision decisions increases the reliability of navigational information and permits making right decisions, thereby increasing safety at sea.

1 INTRODUCTION

The collision occurred on 31st May 2003 to the north from Bornholm by day with visibility over 10 nm. The distance from the place of collision to the nearest navigational danger in the form of a shoal is equal to 3 nm. There were also a few fishing vessels in the area, the traffic parameters of which did not constitute immediate threat of collision with any of the vessels. Figure 1 presents the location of the vessels at the moment of collision.

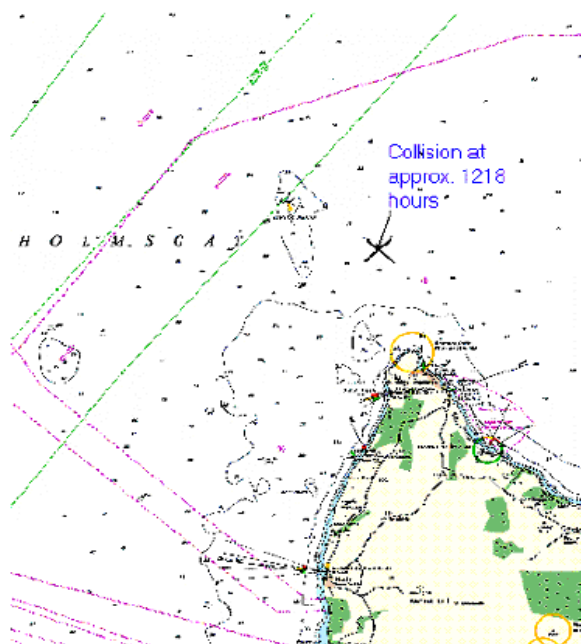


Fig. 1. Location of vessels at the moment of collision
Source: Danish Maritime Administration – www.dma.dk

Figure 2 presents both vessels' position from 1200 hrs up to the moment of collision reconstructed on paper chart based on data from the report by Danish Maritime Administration. Below the photograph there is a table 1 that presents the traffic parameters of these vessels.

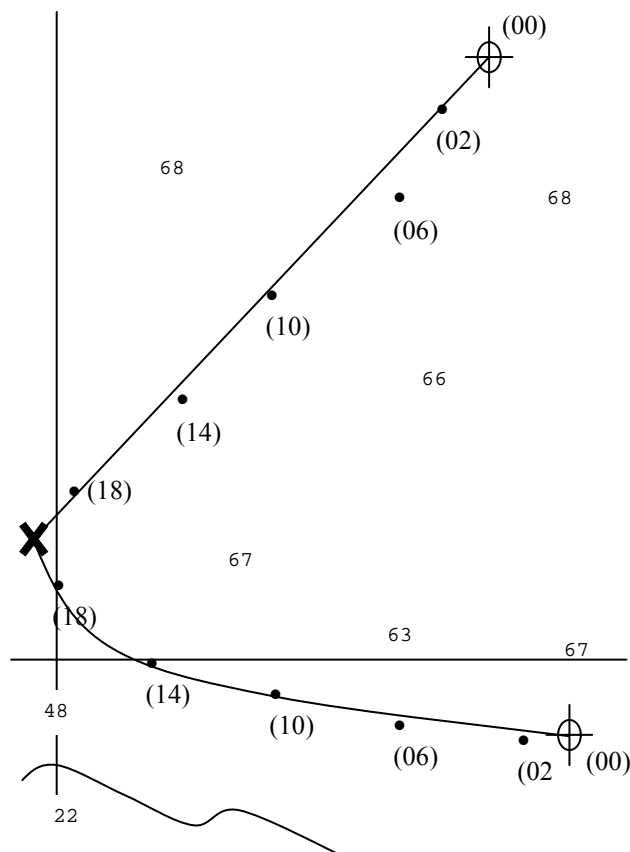


Fig. 2. Reconstruction of vessels position on paper chart

Table 1. Tabular reconstruction of collision situation parameters

GDYNIA			FU SHAN HAI (data from ARPA plot on board GDYNIA)					
Time local	Course	Speed	Distance	Bearing	Course	Speed	CPA	TCPA
1205	280°	13.5 kts.	2.9 n.m.	356°	237°	13.4 kts.	0.4 n.m.	
1206	280°	13.5	2.6	357°	236°	13.3	0.5	15.4 min
1207	280°	13.5	2.5	357°	236°	13.4	0.5	14.8
1208	279°	13.6	2.3	358°	236°	13.5	0.5	13.9
1209	279°	13.6	2.2	358°	238°	13.6	0.4	13.3
1210	280°	13.7	2.0	359°	237°	13.9	0.4	12.4
1211	282°	13.7	1.9	002°	236°	13.3	0.4	10.8
1212	295°	13.6	1.7	003°	230°	9.9	0.7	7.2
1213	295°	13.9	1.5	006°	234°	12.0	0.5	6.3
1214	301°	13.6	1.3	008°	236°	12.4	0.4	5.5
1215	305°	13.6	1.1	010°	241°	11.3	0.3	4.5
1216	313°	13.6	0.8	013°	237°	11.1	0.2	3.0
1216.5	322°	13.6	0.6	016°	241°	9.3	0.2	2.2
1217	326°	13.6	0.5	018°	241°	8.3	0.1	1.8
1217.5	335°	13.6	0.4	021°	238°	6.6	0.1	1.3
1218	350°	13.6	0.3	027°	231°	5.1	0.1	0.7
1218.5	Collision							

Source: Danish Maritime Administration – www.dma.dk

2 MULTIAGENT DECISION SUPPORTING SYSTEM IN COLLISION SITUATIONS

The structure of the system has been so prepared that it permits a parallel performance of tasks bound with supporting decision processes in the conduct of the vessel. The main element of the advisory system on every vessel is the managing module. This is a cooperation agent with the following tasks:

- 1 detection of occurrences on the basis of AIS information,
- 2 assigning a task to the module (modules) responsible for a given kind of occurrence,
- 3 control of tasks assigned, time regimes included,
- 4 communication with cooperation agents on other vessels,
- 5 communication with the operator.

The next system element is the information agent. Its task is a continuous listening watch on AIS and GPS (Global Positioning System) frequencies. After receiving the message it transforms it into a format readable for other agents, at the same time extracting data and eliminating those which are unnecessary in further process and would unduly lengthen calculation time.

The module of occurrence identification is a navigational agent. On the basis of data obtained from the information agent, *inter alia* positions, courses and speeds of own and foreign object, the vessel's navigational status, it determines the vessels' mutual location, encounter parameters like CPA (Closest Point of Approach) and TCPA (Time to Closest Point of Approach) and determines way priority for a vessel. Information on vessels in relation to which we have priority of way and to which we must give way is transmitted back to the cooperation agent.

At the same time the other navigational agent, i.e. manoeuvring module, calculates new movement parameters of our vessel, permitting the passing of the set CPA. New courses and speeds are fed back to

the cooperation agent, who makes a decision whether to keep present course and speed or to perform an anticollision manoeuvre.

The last element of the multiagent system is the execution module, the task of which is to control the vessel's propulsion and steering devices. This module is operated by the navigator himself. In future, these activities, too, could be performed automatically.

The input data for the algorithm and the programme is the following information from AIS and GPS systems:

- 1 for vessel identification:
 - MMSI number - Maritime Mobile Service Identity,
- 2 for designating the vessel's movement elements:
 - geographic position,
 - course over the ground,
 - true course,
 - speed over the ground,
 - time of forming the information package,
- 3 for detecting the vessel's manoeuvre:
 - the vessel's angular speed,
- 4 for determining the predicted trajectory of the vessel's movement:
 - planning the vessel's route with all way points from the port of leaving to the port of destination,
- 5 for accurately determining encounter parameters:
 - locating the antenna in relation to the vessel's bow/stern,
- 6 for determining the degree of privilege between vessels:
 - the vessel's navigational status.
 - 0 – at berth (moored), at anchor, grounded,
 - 1 – not under command,
 - 2 – hampered,
 - 3 – restricted by draft,
 - 4 – catching fish,
 - 5 – sailing boat underway,
 - 6 – mechanically propelled, underway.

The output data are:

- 1 suggestions for course alterations which, with maintained speed, lead to passing clear of all objects on the set CPA,
- 2 suggestions for speed alterations which, with maintained course, lead to passing clear of all objects on the set CPA,
- 3 minimal-time suggestion for own vessel's movement parameter alteration (course or speed) which leads to passing clear of all objects on the set CPA and fulfils the task of optimisation.

3 ASSUMPTIONS FOR SIMULATION

All information used for simulating the encounter of two vessels is derived from the report by Danish Maritime Administration placed at web page www.dma.dk. The simulation was implemented at ECDIS laboratory of the Maritime University at Szczecin on a navigation manoeuvring simulator

Navi Trainer by firm Transas Marine, designed for carrying out training tasks resulting from the requirements of STCW 78/95 Convention. Navi Trainer Professional programme works in an integrated network environment based on Windows NT operational system. Devices for simulating radar work, ARPA, ECDIS, gyrocompass, the log, GPS receiver and other navigational systems and devices meet all applied functioning standards accepted by IMO and international conventions.

On the basis of mutual location and vessel movement parameters at 1205 hrs, the system qualified the encounter as intersecting courses and pointed out “Gdynia” as the give way vessel, in accordance with rule 15 of COLREG. For this reason, a manoeuvring suggestion was prepared for vessel “Gdynia”, assuming that the other vessel maintains her course and speed (COLGREG rule 17). The procedure determining way priority was described in detail in (Wolejsza P. 2005b).

The following parameters for performing simulation were assumed:

- 1 distance of passing clear CPA = 1852 m (1 nm),
- 2 good visibility,
- 3 maximum speed – 15 knots,
- 4 minimum speed – 0 knots,
- 5 minimum course alteration – 20°,
- 6 maximum course alteration – 90°,
- 7 LOA “Gdynia” – 101 m,
- 8 LOA “Fu Shan Hai” – 225 m,
- 9 location of “Gdynia” ‘s radar antenna - 85 m from the bow,
- 10 “Fu Shan Hai” ‘s superstructure situated 200 m from the bow is the vessel’s echo visible on the radar screen, in relation to which ARPA calculates encounter parameters (in theory, the superstructure of a loaded bulk carrier should give the strongest echo).

The speed interval was determined on the basis of “Gdynia” ‘s manoeuvring data. The service speed of this vessel is 15 knots. The minimum speed excludes movement of the vessel astern. The interval of recommended course alteration was determined so as to be clear and visible (20°) on the one hand, and on the other hand (90°) that it should not make it necessary to turn back from the course chosen.

On the basis of data contained in the table 1 simulation was carried out in order to determine encounter parameters and possible collision-prevention manoeuvres at particular moments of time. Manoeuvring elements (kinematic equations) were not taken account of in the solution.

4 SIMULATION RESULTS

On the basis of assumptions the system worked out solutions of the collision situation, presented in Table 2.

Table 2. Encounter parameters and anticollision manoeuvring suggestions worked out by the system.

Local time	ARPA obtained encounter parameters		System calculated encounter parameters		Solutions suggested by decision support system		
	CPA [nm]	TCPA [min]	CPA [nm]	TC-PA [min]	Course alteration to star-board [°]	Course alteration to port [°]	New speed [knot s]
1205	0.40		0.29	17.5	340.6	252.8	8.4
1206	0.50	15.4	0.33	15.3	349.4	252.9	7.5
1207	0.50	14.8	0.30	14.7	351.3	248.8	7.4
1208	0.50	13.9	0.32	13.6	358.3	246.5	6.9
1209	0.40	13.3	0.25	11.2	359.0	237.0	7.1
1210	0.40	12.4	0.21	10.1	008.5	237.4	6.2
1211	0.40	10.8	0.38	10.4	020.5	249.9	4.6
1212	0.70	7.2	0.59	7.2	039.7	275.0	1.1
1213	0.50	6.3	0.36	6.4	054.2	258.8	lack
1214	0.40	5.5	0.19	5.4	lack	248.2	lack
1215	0.30	4.5	0.18	4.8	030.1	280.0	3.3
1216	0.20	3.0	0.10	3.0	lack	268.1	lack
1216.5	0.20	2.2	0.06	2.3	048.7	295.6	1.2
1217	0.10	1.8	0.04	1.9	lack	291.8	lack
1217.5	0.10	1.3	0.03	1.4	lack	286.4	lack
1218	0.10	0.7	0	1.0	lack	lack	lack
1218.5	collision						

Remarks:

- 1 Results marked in boldface in the table for CPA value = 0.5 nm.
- 2 Results marked in boldface in the table and justified were obtained for CPA value = 0.25 nm.

Comparing encounter parameters CPA and TCPA obtained from ARPA and decision-support system it can be stated that:

- 1 CPA presented by ARPA is always larger than the CPA calculated by the system,
- 2 TCPA values approximate each other.

Differences in CPA values are due to the vessel’s length being taken account of when calculated by the system. Information on the vessel’s size and antenna location is taken from AIS system. Both in ARPA and in the formulae presented in (Lenart 1999), on the other hand, the vessels are treated as points; hence the overstatement of results which can translate into erroneous estimation of situation by the navigator, particularly in the encounters of large vessels, among which the “Fu Shan Hai” was counted.

The largest CPA difference in the table equals 0.21 nm, which with CPA value of 0.4 nm constitutes an error of over 50 per cent. On smaller vessels like “Gdynia” the smallest passing distance on the

level of 0.5 nm is often considered as safe. Such value was obtained from ARPA by "Gdynia" 's Second Officer in the third, fourth and fifth minute of tracking and which was probably why he did not undertake any action, considering the situation as safe.

TCPA values obtained from both system are close to each other, as the vessel's size does not affect the moment of contact, only its value.

5 ANALYSIS OF RESULTS

At 1205 hrs local time the vessels were in a distance of 2.9 nm from each other and the CPA according to ARPA was 0.4 nm. In result of the system's work the following results were obtained: in order to pass each other at 1 nm distance, "Gdynia" 's watch officer could make a choice between altering course to starboard by 61°, or to port by 27°; a speed reduction manoeuvre was still viable at this distance, but as it is practically rarely used in the open sea, it will not be discussed in more detail. In the subsequent (06-08) minutes CPA rose to 0.5 nm, although it was actually on the level of 0.3 nm. Only at 1209 hrs, when the CPA started decreasing, did vessel "Gdynia" begin to alter course to starboard by 25°. According to the system's calculations, in order to pass "Fu Shan Hai" astern in a distance of 0.5 nm or 1.0 nm the course should be immediately altered by respectively 44° or 80°. Thus, the action undertaken was insufficient. At 1210 hrs vessel "Fu Shan Hai" issued 5 short blasts; she must have not noticed that "Gdynia" started altering course. At 1213 hrs, when "Gdynia" had altered her course by about 15° this fact went unnoticed on vessel "Fu Shan Hai", which is why the master decided to stop engine. He did not notify other vessels about it; the manoeuvre could be noticed neither visually nor by radar. At 1215 hrs the vessels were at a distance of 1.1 nm from each other. As the system did not find a solution permitting the vessels to pass each other in a distance of 1nm, he reduced the assumed CPA by 50%. In this situation, altering course immediately to starboard by 85° and to port by 25° ensured respectively passing astern and ahead of the vessel. Two minutes before the collision "Gdynia" continued turning to starboard and was on a course of 322°. "Fu Shan Hai" was decreasing her speed, which is why, in order to pass her astern at a distance of 0.25 nm, the course should have been altered by at least 87°. An effective anti-collision manoeuvre by altering course to port was sheerly theoretical, as the rudder had been put to starboard. A minute before the collision "Gdynia" continued altering course to starboard (at the moment of collision she was on a course of 350°), and "Fu Shan Hai" continued to reduce her speed. From collision avoidance point of view both manoeuvres were neutralizing each other and eventuated in

"Gdynia" striking the port of the other vessel making it sink.

6 CONCLUSIONS

The case described proves that the application of AIS for estimating the situation would have permitted the avoidance of collision. "Fu Shan Hai" would have noticed "Gdynia's" altered course thanks to the angular speed parameter, and "Gdynia" would have noticed "Fu Shan Hai's" speed reduction. Such information is not provided by ARPA.

This does not change the fact that the vessel to give way tarried with undertaking proper measures according to the situation (non-compliance with rules 8, 15, and 16 of COLREG). This may have been due to erroneous estimation of the situation, based mainly on ARPA information (breaking rules 5 and 7), which eventuated in undue nervousness of the other party, resulting in ill-judged decisions (action non-complying with rule 17) and leading to collision.

Whereas AIS information would have helped to estimate the situation properly, then the use of vessel traffic parameters obtained from AIS for working out the manoeuvre would have provided ready solutions for the collision situation. Even inaccurate ARPA data would have permitted the preparation of effective solutions by a multiagent system of decision support in collision situations. Course alteration to starboard at 1209 hrs by at least 44° instead of 25° had the following advantages:

- 1 the manoeuvre was definite and clearly visible for the other vessel,
- 2 it permitted passing astern of "Fu Shan Hai" at a distance of 0.5 nm (in the case of assumed CPA being 1.0 nm, the course should have been altered by 80°),
- 3 successive course alterations would have been avoided (rule 8b),
- 4 seeing "Gdynia" 's definite manoeuvre, "Fu Shan Hai" would not have started the manoeuvre of speed reduction.

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