DE GRUYTER OPEN

DOI: 10.1515/aon-2015-0006

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THE INFLUENCE OF RADAR PICTURE STABILIZATION TYPE TO ANTI-COLLISION MANOEUVRE PLANNING ACCURACY

ABSTRACT

The problem of the accuracy of anti-collision manoeuvres planning and executing at different radar picture stabilization methods (sea or ground stabilization) is described in the article. The analysis of performance standards elaborated for the radar equipment and the results of the simulation are presented. The obtained research results could be the base of discussion on the need to correct the radar equipment performance standards for easier and more appropriate interpretation of information. Basic radar utility use (for example trial manoeuvre) should be more clearly described in manuals for better and proper radar use.

Keywords:
radar, anticollision, accuracy.

INTRODUCTION

The possibility of achieving information about situation around a ship from many different sources is characteristic for navigation nowadays. It is usually possible to join and present it at one screen (e.g. ECDIS, ARPA), so that navigator has to know current system settings and be able to interpret correctly data presented on the screen. Their task is also about configuring appropriately devices' parameters, adequate to current needs and conditions. In case of radar devices it is undoubtful that there are parameters which have great influence on a way of interpreting information, such as the type of used motion mode (true or relative), orientation (North-Up or Course-Up) and type of true motion stabilization (ground or sea stabilization).

Resolution IMO A.823 introduced requirement of providing both types of stabilization (sea and ground stabilization), in radar devices with automatic target tracking. It was also confirmed in Resolution MSC.192.

Radar and ARPA are used both for anti-collision purposes and for navigational purposes. The requirements for 'ground-stabilization for navigation' and 'sea--stabilization for collision-avoidance' seem to exclude each other. The problem of radar picture stabilization became even more important by the introduction of ARPA, by the use of video map overlays and by the introduction of complex integrated navigation systems including radar [Berking B., Pfeiffer J., 1995] and AIS.

Operator should know differences between AIS data and data gathered from tracking radar echoes and should be able to choose type of information consciously, while they can both be presented on the radar screen simultaneously. They have to be aware, that some of the data might concern over the ground true motion data (AIS data), and the other displayed vectors present true motion at sea stabilization (tracking targets) [Berking B., Pfeiffer J., 1995; Bole A. G., 2007]. Such data combination additionally might cause difficulties in proper interpretation, the more they're not always properly described. Collision situation might be misinterpreted and decisions might be incompatible with COLREGS regulations and also ineffective.

So that, navigator, while analysing situation, should take special attention to appropriate information type selection (considering the task which is to do). While planning anti-collision manoeuvres navigator should base especially on data of sea stabilized targets movement [Berking B., Pfeiffer J., 1995; Stateczny A., 2011]. Such a view is common in many publications. However, regulations included in previously mentioned IMO resolutions don't point out clearly which type of data should be used (sea or ground stabilization) while using trial manoeuvre function [Resolution MSC.192(79), 2004]. It results in some freedom of solutions applied by manufacturers. In addition manuals lack of clear tips about what navigator should focus on in order to use trial manoeuvre function in an appropriate way. Manoeuvre planning at ground stabilization might lead to dangerous reduction of distance to Closest Point of Approach (CPA). It is especially dangerous when navigators too much trust in their devices and they accept reduced CPA values as safe (especially at reduced visibility). Of course misinterpretation of information, their types confusion or too much trust for data precision are group of people's common mistakes, which will always happen. That is why it is essential to mention topics, which are still not clear among the navigators, and sometimes are the source of their mistakes.

It should be also noted the apparent lack of literature and research in this field, which can be explicitly appointed. As a result of this state of affairs there are many discussions conducted both by navigators and sailors on the internet forums.

Expressed by them opinions and suggestions are often contradictory and do not allow then extract the correct conclusions.

This article stands as an element of discussion about different types of target' data using which should lead to clarification regulations about unification of ways of informing user about the type of displayed data as well as about a way of trial manoeuvre function implementation, so that users didn't have to analyse on their own which type of data is presented by indicator (and that, as previously mentioned, can lead to wrong conclusions).

PERFORMANCE STANDARDS ANALYSIS

In case of radar devices with automatic targets tracking basic technical requirements are included in MSC.192 Resolution and SOLAS Convention.

Analysing statements of MSC.192 Resolution we can conclude, that true motion is basic form of presenting information nowadays, as relative motion presentation was defined as some specific form of true motion, for which own ship's position had been stopped on a radar's screen [Res. MSC.192, par. 5.20.1]. According to these expectations radar devices should provide situation display both to sea and ground stabilization. It should be remembered that the type of stabilization concerns to true motion. Function based on isolated ground target tracking was pointed out as one way of gaining ground stabilization [Res. MSC.192, par. 5.25.4.8].

For assurance of possible correct interpretation of information, active indication should be provided for selected picture presentation, orientation and stabilization modes and source of information about stabilization should be pointed out.

Information about targets can be obtained by radar echoes tracking or from Automatic Identification System (AIS). The main difference, as a result of stabilization mode, concerns true target data. There are no doubts in case of data from AIS (these data have to concern to ground stabilization), however in case of radar tracking the type of data is connected with the type of stabilization chosen by the navigator (ground or sea stabilization). Providing a possibility of automatic joining object data (based on customized criteria) is also required in order to prevent presenting two symbols for one object. Practically it ends up with object's data comparison (AIS-radar) and if differences are between acceptable borders, then only the symbol/vector chosen by the navigator in system settings is displayed on the screen.

Trial manoeuvre utility is required for radar systems installed at the ships over 10000 gt. [SOLAS Conv. Chapt. V Reg. 19, par. 2.8]. This function should provide simulation of predicted own ship's manoeuvre effect in potentially dangerous situation and should also include own ship's dynamic characteristic (inserting requirements about own ship's dynamics should provide better precision of planned manoeuvre effects valuation). Turning on the trial manoeuvre simulation mode should be pointed out clearly on the screen. It should be possible in trial mode to simulate change of own ship's course and speed and present time left to manoeuvre's begin with its countdown. During the simulation, target tracking process should be continued and present objects' data should be displayed. Trial manoeuvre should be available for all tracked targets and at least all active AIS objects.

In submitted requirements about presenting information and trial manoeuvre, there are none, which would standardize the way of using this function for different types of radar picture stabilization modes (sea or ground stabilization) or at least limit their usage in an inappropriate way. Because of the fact that this function is required for big ships, accurate manoeuvre planning is especially essential, without gained information's precision deterioration. Clear formulation of requirements about trial manoeuvre function in documents containing performance standards for radar equipment and the need of describing correct way of interpreting information in radar equipment manuals seem to be most important here. It would limit the variety of common solutions, which currently leads (while lacking essential information in manuals) to difficulties in correct rating of planned manoeuvre's effects.

ASSUMPTIONS AND COURSE OF AN EXPERIMENT

During research, simulations were done in order to try rating in which degree misinterpreted information about a type of radar picture stabilization might influence the precision of planning and anti-collision manoeuvre execution. It is worth re-minding, that it is not caused by errors of radar equipment used by navigator, but by misinterpretation of presented information (in this case not proper consideration the type of radar picture stabilization). Due to earlier mentioned expectations (or rather their little precision) making these mistakes is very likely, especially considering a way of making anti-collision manoeuvres (steering at sea stabilization). In order to define differences arising, while planning and making anti-collision manoeuvre, constant value of planned CPA_{LIMIT} was assumed, regardless the fact if planned manoeuvre may be called as substantial or not.

Simulation experiment was made in NMS-90 simulator. During the experi-ment ARPA Furuno 2815 device was used. It was assumed that during the simulation the ground stabilization was obtained by fixed land object tracking (REFERENCE TARGET function) [Furuno Operator's Manual, Japan]. Trail manoeuvre function in this device is realized in static form (without considering own ship's manoeuvre parameters) [Chrzanowski J. et al., 2010; Furuno Operator's Manual, Japan]. The time needed to make trial manoeuvre was not considered as well. Because of that the base for CPA valuation after manoeuvres execution was the distance obtained during the simulating scenario without inserting drift parameters and anti-collision manoeuvre at sea stabilization.

Unfortunately, there is no information in ARPA's manual about a way in which it should be interpreted the information obtained during simulating trial manoeuvre with usage of TRIAL function at ground stabilization [Furuno Operator's Manual, Japan]. While on the radar's screen there are no correct, clear descriptions, which (especially in case of unexperienced navigator) can cause misinterpretation of information making pointed out manoeuvre in a wrong way. Similar deficiencies are not an exception and can be found in many other radar/ARPA manuals.

During the ships' movement simulation (own ship as well as tracked target) mathematical model of bulk carrier was used. Her parameters are:

Overall length 174.0 m
Width 31.1 m
Draft 12.0 m
Displacement 54600 t
Full ahead speed: 14.5 w

Two collision scenarios were simulated (CPA = 0) which differed with the type of meet (ship on opposite courses and crossing courses situation). Data at the beginning of simulation are described in table 1. In each scenario a fixed target was simulated, which allowed to obtain ground stabilization.

Table 1. Test scenarios characteristic — initial data

Scenario	Own ship		Target		Initial target position		Passing parameters	
	True course [°]	True speed [w]	True course [°]	True speed [w]	Bearing [°]	Distance [NM]	CPA [NM]	TCPA [min]
1	000,0	14,5	180,0	14,5	000,0	8,7	0	18
2	000,0	14,5	270,0	14,5	045,0	6,5	0	19

For each scenario 9 types of simulation were realized, with different drift direction. The base situation was scenario without any drift and in next 8 variants the direction was changed by 45° for each next simulation, with constant value of 3 kn.

Anti-collision manoeuvre with use of TRIAL function was made during each simulation. Anti-collision action was planned when tracking process had stabilized and tracked object reached 5 NM distance from own ship. It was assumed that planned manoeuvre will rely on change course to starboard. Despite the fact, that in the window containing planned manoeuvre's parameters were shown ground course and ground speed, read value of new course was put to an autopilot as proper anti-collision manoeuvre parameter. When anti-collision manoeuvre was completed and tracking was stabilized, really obtained CPA value was registered.

EXPERIMENT RESULTS

During these simulations values of planned anti-collision manoeuvres were registered, as well as really obtained passing distances (CPA). In both scenarios, the base of rating was the planned manoeuvre without a drift. Registered results of planned manoeuvres are contained in table 2.

Table 2. Planned anti-collision manoeuvres

Scenario	Drift parameters		Planned manoeuvre [°]	Scenario	Drift parameters		Planned manoeuvre [°]
	Direction [°]	V [kn]			Direction [°]	V [kn]	
1	000,0	0,0	024,0	2	000,0	0,0	024,0
1A	000,0	3,0	018,0	2A	000,0	3,0	020,0
1B	045,0	3,0	027,0	2B	045,0	3,0	025,0
1C	090,0	3,0	034,0	2C	090,0	3,0	032,0
1D	135,0	3,0	039,0	2D	135,0	3,0	032,0
1E	180,0	3,0	029,0	2E	180,0	3,0	027,0
1F	225,0	3,0	019,0	2F	225,0	3,0	020,0
1G	270,0	3,0	015,0	2G	270,0	3,0	015,0
1H	315,0	3,0	012,0	2H	315,0	3,0	014,0

In both scenarios planned anti-collision manoeuvre with sea stabilization was course changing about 24° to the starboard.

In scenario nr 1 (ships on opposite courses) during other variants realization, new course values laid between –12° ÷ +15° in comparison to the basic situation (without drift simulation).

In scenario nr 2 (crossing situation) during other variants realization, new course values laid between –10° ÷ +12° in comparison to the basic situation (without drift simulation).

The differences in CPA in all variants with a trend line for both scenarios is shown at figure 1.

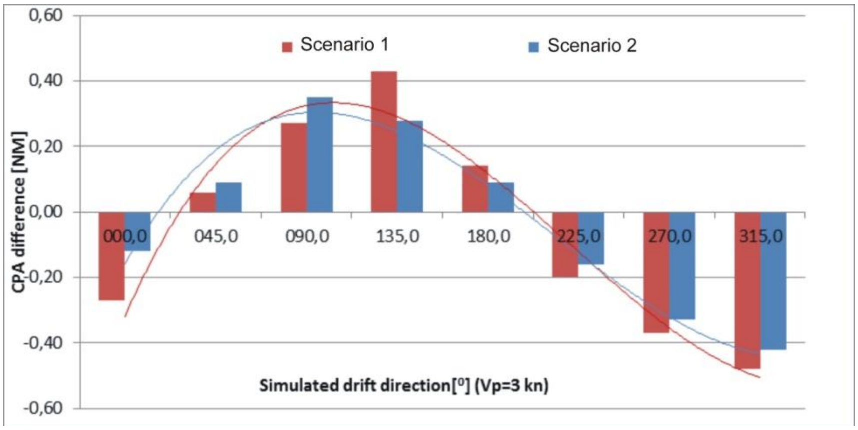

Fig. 1. Differences in CPA value obtained after anti-collision manoeuvre execution — scenarios 1 and 2

During data analysis it could be seen when a drift direction differing from own ship's course by about 10°–190°, the passing distance's value increased in comparison to planned value (maximum increase amounts to 0,43 NM in CPA value in scenario 1 and 0,35 NM in scenario 2). On the other hand (what is far more important in ship's safety) for all other drift directions it was registered that obtained CPA value decreased according to before planned (even by 0,48 NM in scenario 1 and 0,42 NM in scenario 2).

RESULTS ANALYSIS

Planning manoeuvre with use of true motion at ground stabilization data and then execution this manoeuvre in a standard way by setting anti-collision course at ship's autopilot device causes differences which can be analysed by preparing radar plotting for both types of stabilization.

Figure 2 presents results of planning anti-collision manoeuvre for situation without a drift and for drift directions: 090° and 270° on relative plotting type. Vector used to plan a manoeuvre was over the ground own ship's vector. Fixed object's position, observed on the screen, was also marked.

As a result of such different planning it could be obtained different solutions. Those differences are presented in figure 3.

a) without a drift

b) Drift
Dir = 090°/Speed = 3.0 kn

c) Drift
Dir = 270°/Speed = 3.0 kn

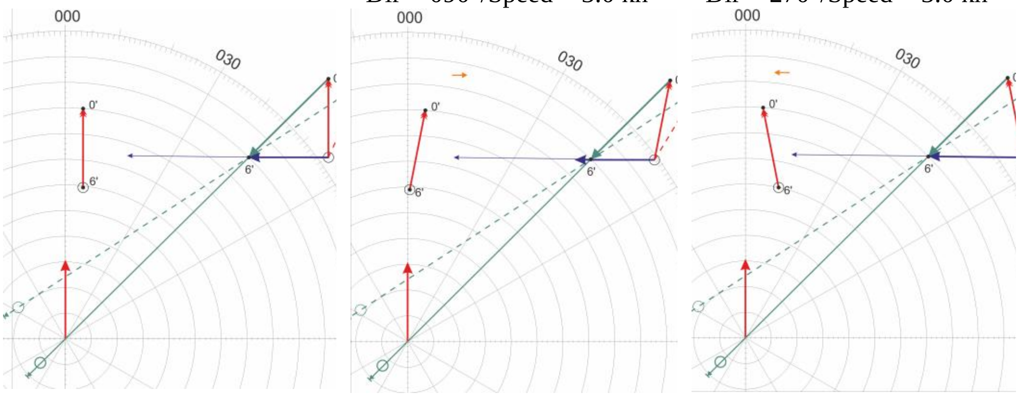

Fig. 2. Anti-collision manoeuvre planning for different drift parameters with use of own ship's course and speed information stabilized over the ground

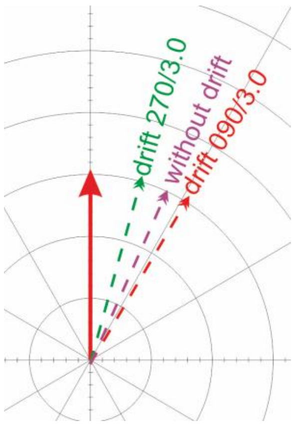

Fig. 3. Planning results comparison for different drift parameters (ground stabilization)

Execution of different manoeuvres (without a consideration of drift correction) will lead to obtain different CPA values.

CONCLUSIONS

The analysis of existing performance standards was to identify existing gaps, resulting in differences in the basic ARPA functions implementation by the producers, which in turn can lead to misinterpretation of the presented information. At the moment, there is the opportunity to present on the display (even simultaneously) various types of data (sea or ground stabilized true motion information). Therefore it is important to navigators know how they should make the selection of information and what type of data should be used in the planning of anti-collision manoeuvre when the trial manoeuvre utility is using. In particular, this applies to waters where there are strong currents that cause significant drift of the ship.

According to performance standards for radar equipment, radar devices should provide possibility of obtaining both sea and ground stabilized radar picture [Resolution MSC.192(79), 2004]. Because of that navigator constantly has to consider current device's parameters in this range while judge the situation around the own ship. It is even more important while in case of strong drift values, because presenting situation at ground or sea stabilization may be significantly different. These cases might end up with incorrect situation judgement taking ineffective actions or even against COLREGS rules. Situation is getting even more complicated while there might be differences in types of information about targets' movement (over the ground or through the water) in case of tracked objects and, so called, AIS objects are simultaneously presented at the same screen. Navigator should avoid simultaneous presentation of two different types of information on one screen. It may lead to wrong decisions.

Collision situation analysis and anti-collision manoeuvres planning should be done at sea stabilization mode. Such presentation is more adequate for clear COLREG rules usage. Planned manoeuvres with usage of trial manoeuvre utility are more precise in comparison to obtained results and easier to interpretation.

Difficulties in interpretation results of a trial manoeuvre utility are caused indirectly by a lack of clear performance standards in that regard. It considers at least pointing out clearly the type of stabilization that should be switched on in case of using trial manoeuvre and which type of output data (showing clearly their type) should be displayed on the indicator. Producers should also be clearly obligated to explain correct way of interpreting situation on the screen, so that these information were not only about pointing out a button, which should be pressed in order to turn particular utilities on. Unfortunately, such situation is not uncommon now.

Because the distance closest point of approach (CPA) is the main parameter to be taken into account by the navigators (both in the process of assessing the ship safety as well as the planning and evaluation of the collision avoidance effectiveness) the error of misinterpretation of information by the navigator was calculated for typical collision situations and analysied. The simulations clearly indicated the possibility of a significant reduction in the obtained CPA value and thus reduce the level of security.

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Received September 2014
Reviewed December 2014

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STRESZCZENIE

W artykule przedstawiono problem dokładności planowania i wykonania manewrów antykolizyjnych przy różnych metodach stabilizacji obrazu radarowego. Zaprezentowano analizę standardów opracowanych dla wyposażenia radarowego oraz wyniki badań symulacyjnych. Mogłyby się one stać podstawą do dyskusji na temat kierunków poprawy standardów wyposażenia radaru z zamiarem ułatwienia użycia i poprawniejszej interpretacji informacji. Wykorzystanie radaru (np. dla określenia próbnego manewru) powinno być jaśniej opisane w instrukcjach, jeśli oczekuje się jego lepszego i właściwszego zastosowania.