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THE INFLUENCE OF THE SHIP YAWING ON THE TARGET TRACKING PROCESS

ABSTRACT

Precision of the data obtained in the object tracking process performed by the ARPA systems, depends very much on weather conditions [1, 3, 5]. Main factors resulting from bad weather conditions and having an influence on the precision of object tracking process are ship's rolling and yawing. Results of the experiment conducted in the ARPA simulator, whose objective was to define tracking errors resulting from ship yawing, are presented in this paper.

Keywords:
radar tracking, ARPA.

INTRODUCTION

Basic requirements referring to the ARPA devices are included in IMO Resolution 823(19) [2]. One of the essential points is to define the required precision of target tracking. We have to take into consideration statement included in Resolution that the tracking process should be performed more precisely in case of better, than specified in Resolution, conditions. Nevertheless in this document we are given only maximum values of own ship rolling without taking into account other factor affecting the precision of the tracking process in bad weather conditions, namely yawing of the ship. Sometimes it reaches considerable values, especially in case of small ships. It is the essential because at present more and more ships smaller than 10000 tones are equipped with ARPA systems. These vessels move less stably in bad weather conditions, which affects the quality of the data presented in radar reports.

In this paper, the results of the experiment, conducted in the navigation-radar simulator NMS-90 whose objective was to define the stability and precision of the tracking process in case of the yawing phenomenon occurence, were presented. In the course of studies ARPA 2815 FURUNO was used.

DESCRIPTION OF THE RESEARCH

The subject of the studies was the analysis of the tracking process precision depending on the value of the simulated ship yawing. Testing scenarios were performed in the open sea area without the influence of wind and current. Navigational situations of two ships with similar characteristics (ship model parameters are presented in table 1) were examined. Initial parameters of the simulated scenarios are presented in table 2.

Table 1. Parameters of the ship model used in research [4]

Own ship model	Length [m]	Width [m]	Draught [m]	DWT [T]	Speed [kn]
Bulk carrier (BULKC)	174.0	31.1	12.0	54600	14.5

Table 2. Initial conditions of scenarios

Scenario	Own ship data (course/speed)	Target position (bearing/distance)	Target data (course/speed)	Type of situation
1	0000/14.5 kn	0000/8.5 NM	1800/14.5 kn	head-on situation
2	0000/14.5 kn	0450/8.5 NM	2700/14.5 kn	crossing situation
3	0000/14.5 kn	0000/ 6.5 NM	0000/10.0 kn	overtaking

Testing scenarios represent three typical collision situations of two ships in the open sea area (CPA = 0 NM). They differ from one another in the relative speed of ships. For every scenario various values of the own ship yawing were simulated. The difference lied in the variation of the maximal yawing angle value (1, 3 or 5 degrees) for the constant yawing period of 120 seconds (fig. 1), and the variation of the yawing period (60, 120 and 180 seconds) for the constant yawing angle of 5 degrees (fig. 2). Due to the ship's inertia, the set maximal yawing angle has been exceeded several times during the simulation.

In order to define the precision of the tracking process in conditions where there are no disturbances, a scenario without yawing has been also performed.

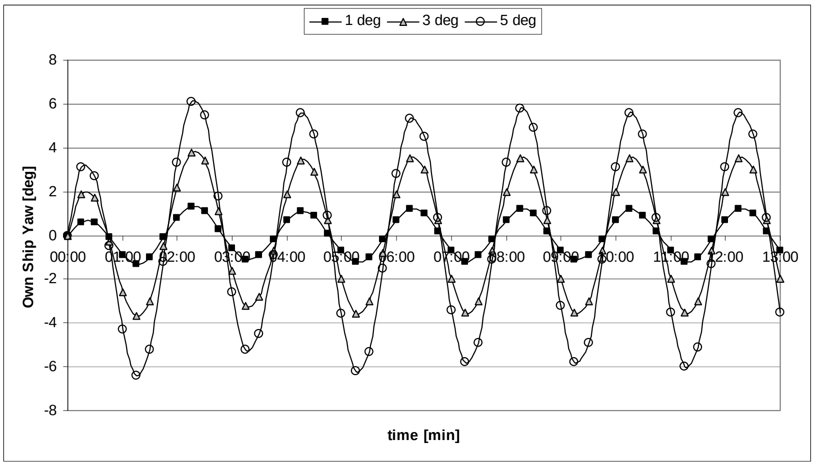

Fig. 1. Simulated own ship yaw for the period of 120 s

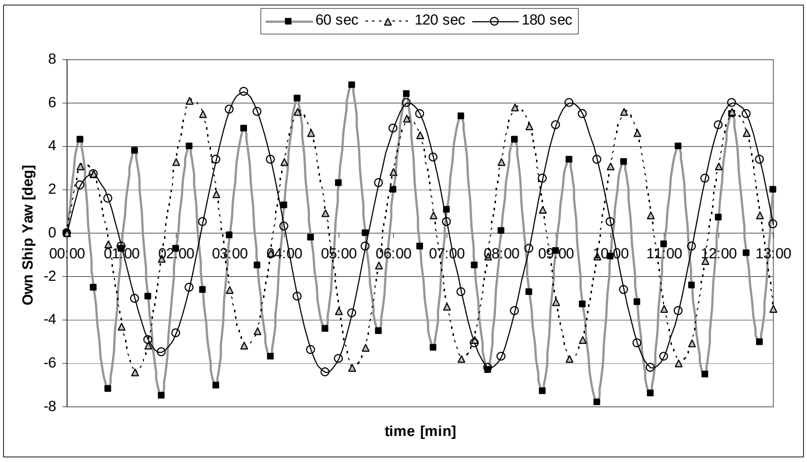

Fig. 2. Simulated own ship yaw for the maximal angle of 5 degrees

EXPERIMENTAL RESULTS

During the simulation the target was acquired after 1 minute from the moment the simulation began. In case of the ARPA 2815 FURUNO, the complete radar report with the possibility of vectors movement display was available after 55–57 seconds from the acquisition.

After the radar report had appeared, values of the true course, true speed and CPA were recorded at 15-second intervals until the 13th minute of the simulation.

Registered measurements allowed to calculate of maximum estimation errors and medium error in the steady estimation period, and also allowed to determine the precision of the course of estimation in comparison to the ship yawing period.

When CPA is concerned, two parameters were registered: the enumerated value, and predicted side of target passing. That's why CPA value is negative in the graphs (when the object passes own ship's port side), although in the radar report CPA value is always positive. Exemplary estimation results are shown in the following figures.

The precision of the true course estimation depending on the own ship yawing period is presented in figures 3 and 4. Grey line shows the course of own ship yawing during the simulation. In the presented graphs, a clear dependence of the estimation courses on the yawing can be observed. In higher relative ship speed values only the time of echo tracking stabilization lengthen, while in case of scenario No. 3 (overtaking) clear oscillations of the true course calculated values in the period responding to the own ship yawing are observed.

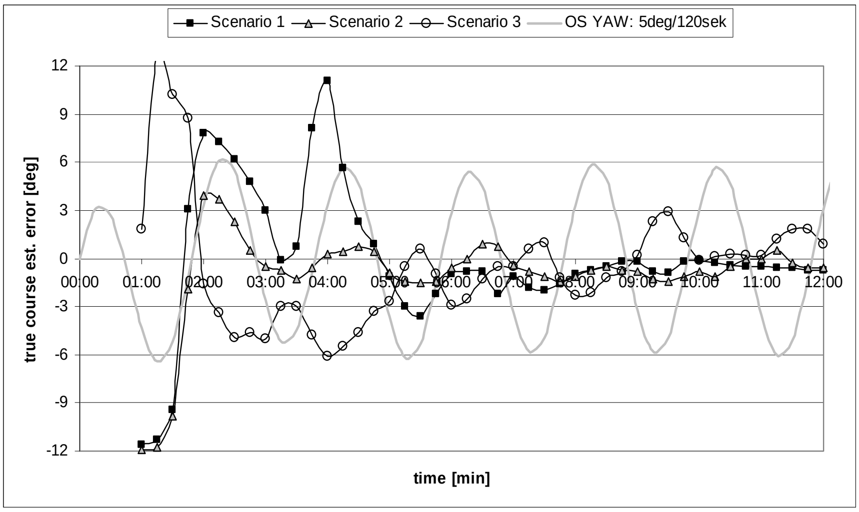

Fig. 3. The true course estimation for 3 testing scenarios at own ship yawing of 50 in the period of 120 s

The mean estimation error of the target's true course (fig. 5) has been calculated for the steady tracking period (form the 3rd to 12th minute of estimation). We have to focus our attention on the high value of the estimation error in testing scenario No. 3 (short period of yawing), although estimation errors themselves do not reach high values, so after the lengthened period of initial stabilization (in comparison to the ideal conditions without the own ship's yawing) the navigator can observe stable true motion vectors.

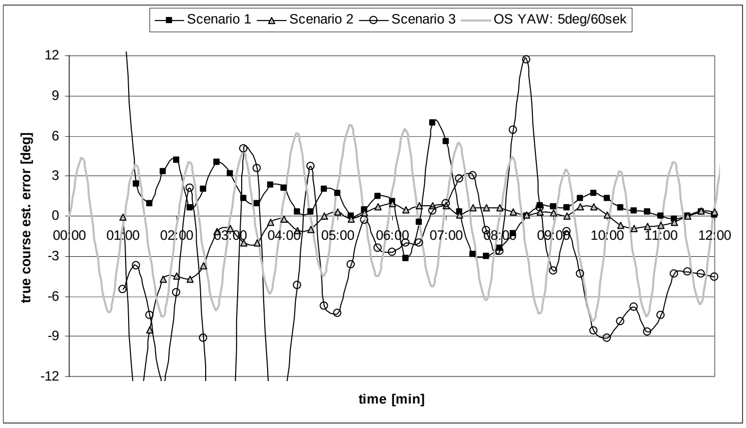

Fig. 4. The true course estimation for 3 testing scenarios at own ship yawing of 5° in the period of 60 second

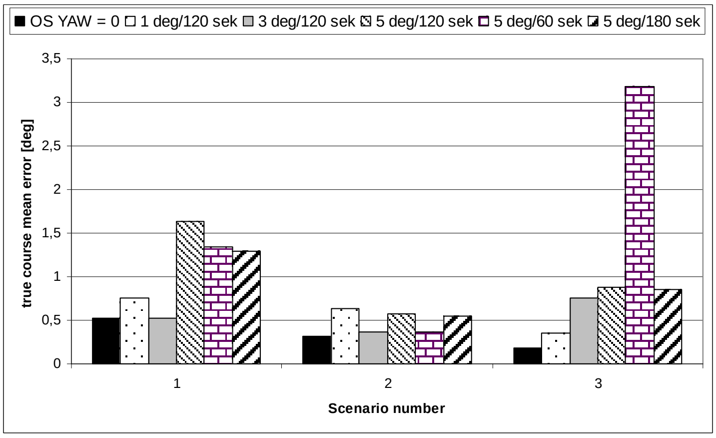

Fig. 5. Mean estimation errors of the object's true course in the steady tracking period

In case of the true speed estimation, the great stability of the estimation cannot pass unnoticed. In fig. 6, the example of the speed estimation for scenario No. 1 is presented. Only the estimation process lengthening is noticeable.

Estimation errors do not reach values higher than allowed, included in the performances for ARPA devices, and their mean values for the fixed tracking period are shown in fig. 7. Mean error values oscillate from 0.15 to 0.4 knots.

When ship's safety is concerned, it is important to precisely and stably estimate CPA value. Examples of the CPA estimation are presented in figures 8 to 10. The greatest CPA estimation errors were registered in testing scenario No. 3 (overtaking). Their values even reach 2 NM, independently of the yawing period (fig. 9) in the whole simulation period. The great variation of values (instability of the tracking process) should be taken in consideration, which, to a significant extent, makes it difficult for the navigator to analyse the situation and execute properly anti-collision manoeuvres. Some time sudden changes of the relative vector direction and even the side on which target will pass, may mislead the navigator. Bad interpretation of the data (especially at short distances between ships and restricted visibility conditions) may lead to collisions.

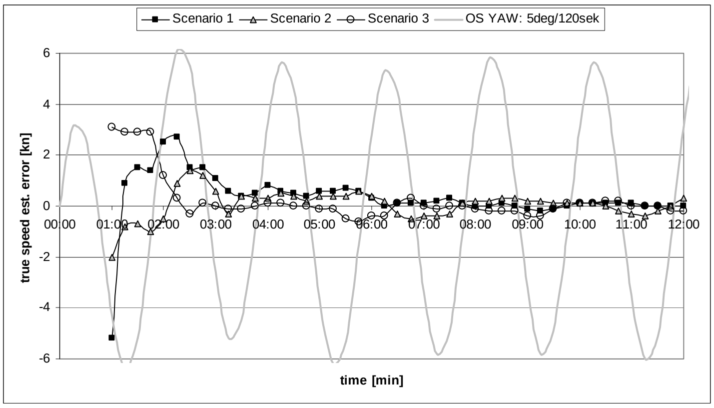

Fig. 6. The true speed estimation for 3 scenarios at own ship yawing of 5º in the period of 120 s

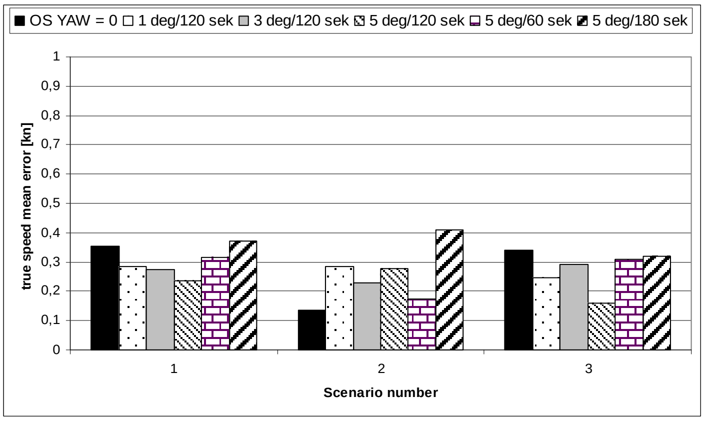

Fig. 7. Mean estimation errors of the object's true speed in the steady tracking period

Such great oscillations of the relative motion estimation were registered in the scenario No. 3. Together with the increase of the yawing angle, in all scenarios the increase of the CPA estimation error values can be recorded, but their mean values do not exceed 0.1 NM. Only in case of passing (relative speed of ships was 4.5 knots) mean value of the estimation errors reaches approximately 0.9 NM, and their maximal values reach even 2 NM (fig. 9 and 10).

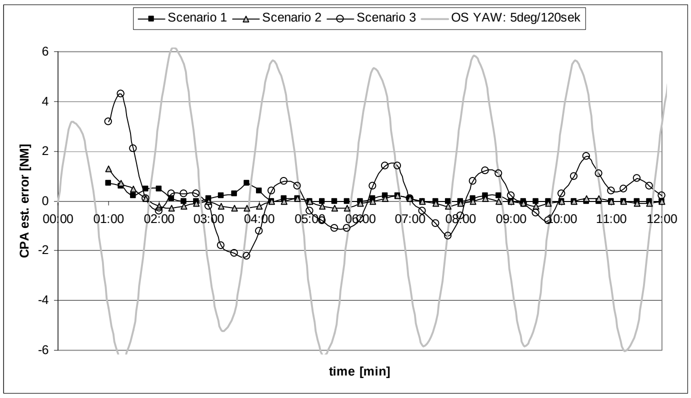

Fig. 8. The CPA estimation for 3 testing scenarios at the own ship yawing of 5º in the period of 120 s

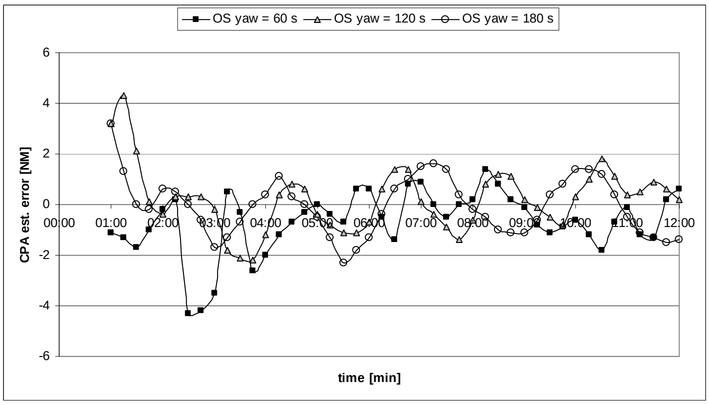

Fig. 9. The CPA estimation (scenario No. 3) when the own ship yawing period changed

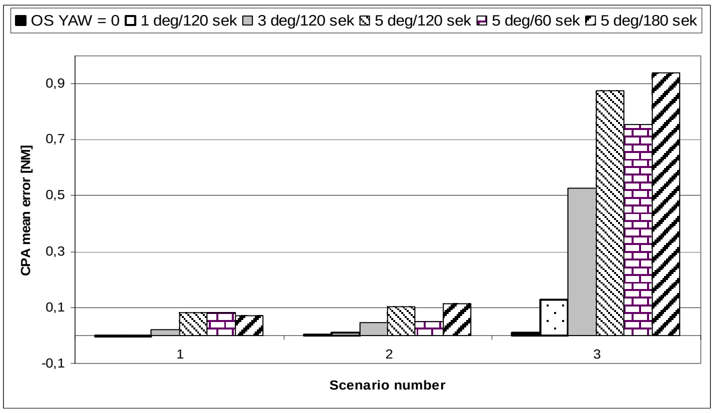

Fig. 10. Mean CPA estimation errors in the steady tracking period

CONCLUSIONS

ARPA devices provide necessary help to the navigator when determining parameters of the tracked vessels motion in the own ship vicinity. On this basis, decisions of executing or not the anti-collision manoeuvres are made. That's why the knowledge of errors which can appear during the target tracking process is so important. Weather conditions are the essential source of errors because they affect the stability of the own ship motion. This concerns especially small vessels equipped with ARPA systems.

The main aim of the conducted experiment was to determine the influence of own ship yawing on the stability and precision of the tracking process. In the course of the simulation both the increase of the tracking errors, and the lengthening of the stabilization time of tracking process according to the ship yawing were fixed.

Shorter yawing period caused less tracking stability. Although in case of the high relative speed objects, tracking errors were within limits allowed by IMO. The greatest tracking errors (especially the CPA estimation) were registered in scenario number 3 when the slower vessel was situated ahead of own ship (overtaking situation). In this situation, due to the great instability of the tracking process, the navigator may have difficulty in interpretation of target data and possible manoeuvres of the tracking object. In situations like these, one should be cautious about ARPA readings.

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