WIESŁAW JUSZKIEWICZ
Maritime University of Szczecin

PRECISION OF SHIP STEERING ALONG A WATERWAY BEND WITH THE USE OF ARPA INFORMATION

ABSTRACT

The usage of stationary object tracking information while steering a ship along a marked waterway relies on the constant estimation of the object passing distance made by the navigator. This information is available both in the alphanumeric form (target data) and in the graphic form (relative vectors). While making decisions, the navigator has to take into consideration the limitations of ARPA devices, particularly delays in transferring information about tracked objects occurring when ships are making manoeuvres. The results of the experiment performed in the radar-navigation NMS-90 simulator, which has been conducted in order to establish the usability of the stationary object tracking information in the process of ship steering along a marked waterway are described in this article.

Keywords: ARPA, Ship's Manoeuvres.

INTRODUCTION

The issue of the right usage of the stationary object tracking information while steering a ship along a marked waterway is essential from the point of view of ship's safety. When using this type of information, the navigator has to take into consideration the limitations of ARPA devices. These limitations are mainly tracking errors (closely connected with hydro-meteorological conditions), and delays in transferring information about tracked objects [1] [2] [4]. In case of stationary objects, it concerns the change of information about the current CPA value during manoeuvring. Therefore, during and just after the manoeuvre, the navigator does not know the distance within which he will actually pass the observed navigational mark. It has a great influence on the precision of steering a ship along a fixed waterway.

In order to check the possibility of using this type of information in making decisions by the navigator, a navigational experiment has been conducted. Navigators had to evaluate the ship's position in relation to the planned route on the basis of the information about tracking stationary objects located uniformly along the waterway. Previously assumed passing distance of navigational marks allowed to use the set of relative vectors to evaluate the current position of the ship in relation to the before planned route.

In case when the ship moves along the marked bend of the waterway , the evaluation can be conducted only on the basis of the closest navigational marks. Example of such evaluation of the ship's position with the use of the variable range marker (VRM) and set of relative vectors, has been shown in Fig.1. Situation 1 occurs when the ship moves along the planned route (assumed CPA for the navigational marks is 0,25 NM). In case when the ship passes the navigational mark to close (situation 2), or too far (situation 3), the navigator should make an appropriate course correction.

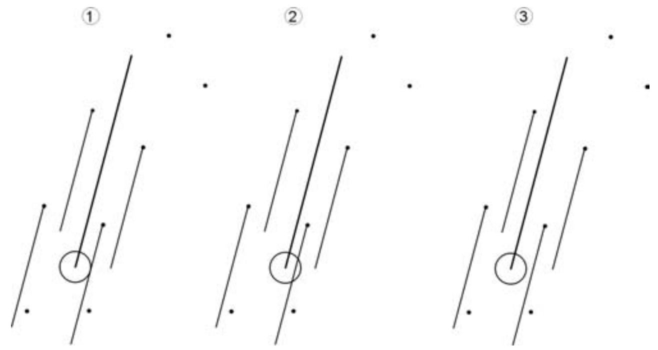

Fig.1. Evaluation of the ship's position based on the presentation of stationary objects' relative vectors

In case of the movement along the linear section of the fairway, when evaluating the ship's position in relation to the planned route, the navigator may also use relative vectors of tracked stationary objects that are situated further (e.g. the next pair of buoys) and their position to one another.

CHARACTERISTICS OF THE COURSE OF THE EXPERIMENT

The experiment has been conducted in a simulated water area in the form of a 1 NM wide curved segment of waterway marked with pairs of buoys (Fig.2). There can be distinguished two scenarios differing in direction in which the ship was sailing during the simulation (along the inner bend with the smaller radius, or outer). Each participant carried out both scenarios, but the sequence of them has been changing.

During the experiment, a mathematical model of bulk carrier, present in the simulator's data base, was used. This vessel is 147 meters long and of 12 meters draft, its full ahead speed (FA) is 14,8 kn [3].

The influence of hydro-meteorological conditions on the ship's movement was not simulated during the experiment (no current or wind).

Navigators participating in the experiment were characterized by the great diversification of professional experience, starting from the fifth year students (with very little professional experience), ending with masters. In all, 15 navigators participated in the research (7 with little and 8 with great professional experience). Each participant of the experiment has been given instructions about the ways of evaluating the navigational situation and planned route.

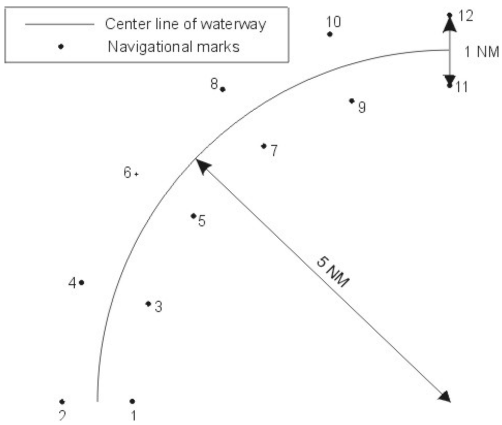

Fig.2. Arrangement of the buoys limiting the waterway used during the experiment

During the simulation, in 15-second intervals, the following ship's parameters have been registered:

– time of the simulation [sec];
– ship's position (latitude and longitude) [deg];

– vessel's course [deg];
– vessel's speed [kn];
– turn rate [deg/min];
– rudder angle [deg];
– distance covered by the vessel [NM].

Registered data enabled to reconstruct the realized routes and calculate the errors made by the navigators. The value of errors was the distance between planned and realized routes.

RESULTS OF THE SIMULATION RESEARCH

Analysis of the registered simulations based on the comparison of errors made by individual navigators and mean errors made in particular groups (taking into consideration the professional experience of the participants), and individually in both scenarios. It is worth mentioning that particular navigators carried out both scenarios, but it took place in various sequences to eliminate the possibility of making minor errors in scenario 2, if it was carried out always as second. All of the registered individual routs of scenarios 1 and 2 have been presented in combined graphs (Fig.3).

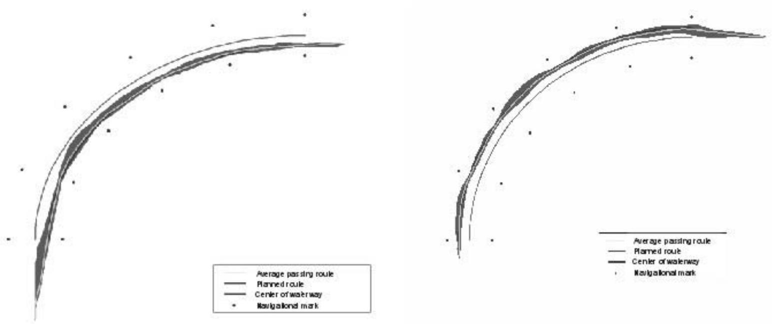

Fig.3. Registered routes realized in scenario 1 and 2.

Very important points of the water area are navigational marks passed by the ship, because they constitutes reference points, on the basis of which the evaluation of the ship's position can be made. Since they are located uniformly, the time of covering particular sections of the track is also similar. Examples of errors made by the navigators are shown in Fig.4 and 5.

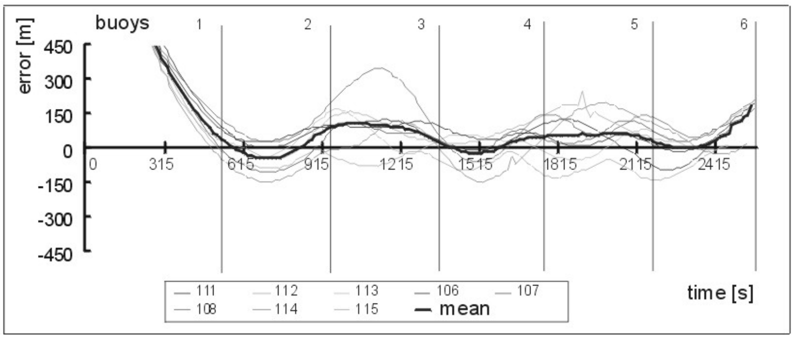

Fig.4. Error of steering a ship along the simulated waterway in scenario 1 – group with great professional experience

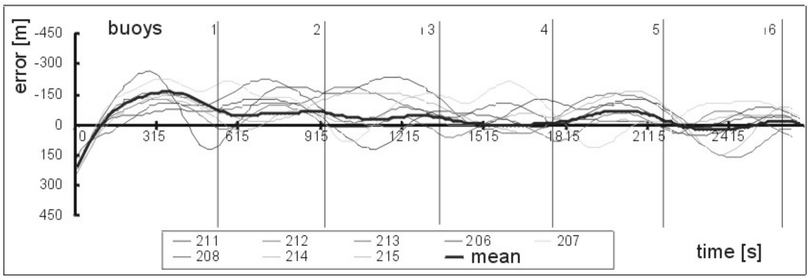

Fig.5. Error of steering a ship along the simulated waterway in scenario 2 – group with great professional experience

Next, maximal errors made by particular navigators during passing the buoys, as well as mean values of these errors for both groups with various professional experience were put together. Example of the specifications of the results is shown in Fig.6 and 7.

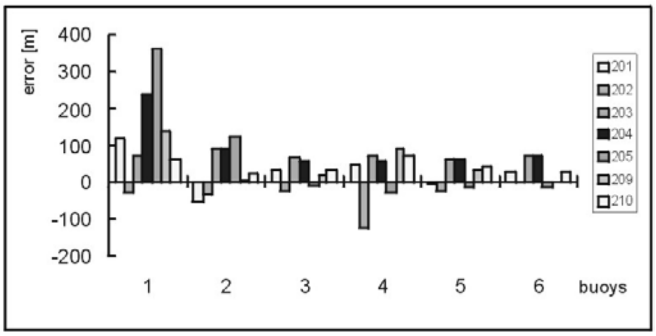

Fig.6. Error of steering a ship along the waterway in scenario 2 during passing the buoys – group with little professional experience

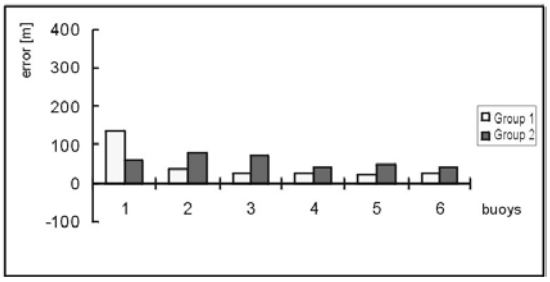

Fig.7. Comparison of mean errors of steering a ship for groups with various professional experience – scenario 2

CONCLUSIONS

In the performed experiment the highest error values occurred always in the sections between the buoys of navigational marking. The error decreased when ships approach the buoy, and next increased after passing it. This type of steering (with the use of rectilinear sections) resulted mainly from steering the vessel parallel to the relative vector displayed for the closest tracked buoy of the navigational marking. Some participants of the experiment trusted projected relative vectors too much, not taking into consideration tracking errors and information delays, which were increasing during the own ship manoeuvre.

Comparing the two scenarios, it is clearly seen that the mean of all recorded routs errors of scenario 1 was higher than the mean of errors of scenario 2. It is so due to the greater distance between the navigational marks (navigators had more time for making decisions).

The water area in scenario 1 as well as in scenario 2 has been safely passed by all participants of the experiment. Maximal position error value registered during the whole experiment was 0,2 NM which, taking into account the area's width 0,5 NM, can be considered safe.

Evaluating the experiment in respect of professional experience, it has been noticed that in scenario 1 group with less experience steered more precisely, whereas in scenario 2 the situation was contrary. However, differences in these errors did not exceed 5,14 meters. It appears that professional experience did not influence the precision of steering a vessel along a testing waterway with the use of ARPA information about tracked objects.

Taking into account the findings' analysis, it can be stated that steering a ship with the use of ARPA devices provides sufficient level of safety on a waterway of 1 NM width.

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Received August 2008
Reviewed November 2008