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Is It Permissible to Use GPS Data to Avoid Collisions?

A. Felski & K. Jaskólski
Polish Naval Academy, Gdynia, Poland

ABSTRACT: Automatic Radar with Plotting Aids is the basic means of preventing collisions at sea for many years. However, the use of the radar on a moving vessel requires image stabilization, which has been at least for the last 50 years solved by coupling with the gyrocompass and the log. In the present century, the widespread use of Global Navigation Satellite System receivers has led to the common practice of interconnecting this receiver with many other systems on ships. This is often also the case for radar, although GNSS gives information about movement related to the ground, whereas the International Maritime Organization recommends using parameters relating to water. The mandatory and widespread equipping ships with the Automatic Identification System means that this system is increasingly used in the process of collision avoidance, but also with the use of ground-referenced data. The aim of the paper is to investigate whether this is acceptable and what are the limits of this practice. This question becomes increasingly important in the context of the growing number of unmanned vessels. Not all, especially small autonomous surface vehicles will be equipped with radar and may also use AIS transmissions in collision avoidance algorithms.
Studies have shown that this may pose a risk of collision. At low ship speeds, if the current speed exceeds 5 knots and the direction of the current significantly deviates from the course of one of the ships, there is a risk that the planned maneuver will not be carried out. This may mean that the closest approach distance will be significantly different from the planned one.

1 INTRODUCTION

From the beginning of the introduction of radars on vessels, their primary application was the detection of objects in the area, primarily to warn of a possible threat. The greatest benefit of implementing radars on civilian vessels after World War II was to obtain more accurate information for collision avoidance, although radar can also be used for positioning a vessel. However, the use of radar on a moving vessel implies the need to take her movement into account, because the interpretation of the image is not very easy. For many years the radar image has stabilized with the use of a gyrocompass, and additionally with the use of a log [1].

The gyrocompass is mentioned above as the source of heading data as it is the most common solution, however, a magnetic compass equipped with special sensors can be used as well. This is a separate issue, because currently there are many different design solutions in gyroscopic technology [2], which entails a different specificity of the oscillation of the course indications, which are natural for gyrocompasses. The use of a magnetic compass with the option of data transmission entails the problem of taking declination and deviation into account, although many modern designs provide the possibility of automatic solution to this problem. According to many analyses published, for example, by [3], a noticeable contribution to the causes of marine collisions comes from the compass. The authors describe their analyses of marine accidents by pointing out that about 10% of collisions resulted from improper operation of vessel compasses. However, this is a deeper problem, because the incorrect operation of the compass can affect the poor operation of the radar or Automatic Radar with Plotting Aid (ARPA), but also the operation of the Electronic Chart Display and Information System (ECDIS) or autopilot, or possibly the work of the officer of the watch or the pilot.

The use of the radar to the avoidance of collisions is a well-known problem and widely described in the literature. Obligatory introduction of the radar with the option of the automatic tracking of targets (ARPA) changed a lot on this field, however still this is the essential problem from the point of view of the safety at sea and are all the time performed much research in this area. The perfect review of methods of the avoidance of the collisions is given in [4].

The problem can be divided into two aspects: collision risk assessment (conflict detection) and the planning of a safety manoeuvre (trajectory planning). These challenges can be addressed using both kinematic and dynamic methods. In many publications risk assessment of the collision is performed based on so-called ship's domain – area around the own ship which is forbidden for the encountered vessels. Other methods are also considered, such as the Dijkstra algorithm, the Artificial Potential Field or A*, but the main difficulty is considering the international collision avoidance rules (COLREGS) [5]. However, in practice more classical methods, based on vector calculus is still in use.

The introduction of the automatic identification system (AIS) on ships altered this landscape by providing a new source of information about the movement of encountered vessel, however this caused the new problem, is which the fusion of the information from two sources [6][7]. This new solution introduced the new trend in the form of the intelligent, decision-making supporting systems [8][9][10].

In turn the common use of the Global Navigation Satellite System (GNSS) on modern vessels has created a completely different situation. This system, commonly interpreted as a positioning system, also provides information about the movement of the object relative to the sea bottom (over the ground). In conjunction with the obvious possibility of automatic transmission of this data in a digital version, the radar is more and more commonly combined with a GNSS receiver and the course over the ground (COG) and speed over the ground (SOG) are transmitted. This is particularly important in relation to the ARPA, which is mandatory equipment for vessels as the basic system supporting collision avoidance. This seems to be an obvious solution in the face of the undoubted appearance of unmanned vessels, in the transport variant Maritime Autonomous Surface Ships (MASS) or the increasingly common surface drones (Autonomous Surface Vehicle – ASV), which are already eagerly used today, especially for various measurements and research purposes. Undoubtedly, the creators of such systems will face the challenge of implementing several very vague convention rules [11][12][13][14], using phrases such as safe speed, good practices, limited trust, etc., combining them with machines operating on similar principles to ARPA or AIS. However, this article, will only focus on the issue of using information about the own vessel's movement in relation to the sea bottom (Speed Over the Ground – SOG and Course Over the Ground - COG). The purpose of the considerations described here is to explain how large errors are introduced by replacing information about the movement through the water with information about the movement overground. This is indirectly related to the AIS system, which is also more and more commonly used to solve anti-collision problems and can be the main source of information on ASV. Theoretically, in this system both COG and SOG are transmitted, as well as course (heading - HDT) and speed through water (STW). However, the author's observations show that much more attention is paid to COG and SOG than to the other two components of the movement. The published results of research into the reliability of data transmitted via AIS prove that the reliability of HDT provided by this system is significantly lower than all other data [15] [16].

Since calculating anti-collision maneuvers require knowledge of one's own ship's course and speed, until the end of the 20th century it was obvious that deck officers (Officer of the Watch – OOW) would use the gyrocompass and water speed log for this purpose, for the simple reason that these means had been widely used. However, when considering the issue of speed measurement, a much wider range of solutions is available and, depending on the meters used, the speed of the vessel can be STW or SOG. In addition, this information can be presented as two components of motion in the plane (forward/back, along the vessel's main axis and lateral speed) or only as a vector in main axis (for or aft direction). In this context, it should be noted that the International Maritime Organization (IMO) Resolution MSC 334(92) [17] specifies as follows:

- 1.1. Devices to measure and indicate speed and distance are intended for general navigational and vessel maneuvering use. The minimum requirement is to provide information on the distance run and the forward speed of the vessel through the water or over the ground. Additional information on the vessel's motions other than on the forward axis may be provided. The equipment should comply fully with its performance standard at forward speeds up to the maximum speed of the vessel. Devices measuring speed and distance through the water should meet the performance standard in water of depth greater than 3 m beneath the keel. Devices measuring speed and distance over the ground should meet the performance standard in water of depth greater than 2 m beneath the keel.
- 1.2. Radar plotting aids/track control equipment requires a device capable of providing speed through the water in the fore and aft direction.

This recommendation is often not respected, and the aim of further research is to analyze the possible effects of replacement of the HDT and STW by COG and SOG. A thorough analysis of world literature does not provide knowledge of any research on this topic. In the further part of the article, the essence of the differences between the use of COG/SOG or course through water CTW/STW in planning a maneuver and the graphical analysis of three cases and the synthesis of the issue based on experiments having been carried out on the simulator are presented.

As the literature does not provide any information on the impact of the use of COG/SOG data on the effectiveness of anti-collision maneuvers, an attempt was made to estimate this factor. The aim of the presented research is to assess this impact, assuming that it is important for system designers to prevent collisions of autonomous ships (both MASS and ASV). This is a related issue that would require separate research, as it appears particularly important in the context of collision avoidance for small Autonomous Surface Vehicles (ASVs), which may not be equipped with radar and will rely solely on AIS-type information exchange. In this article, we did not address these concerns, as the AIS system provides data about the movement of the vessel carrying the AIS device, eliminating the need for additional analysis of the relative movement of the encountered ship.

Unfortunately, the available publications do not address this type of problem. Efforts to combine ARPA and AIS data, often alongside the Electronic Chard Display and Information System (ECDIS), focus mainly on integrating data with different characteristics. These differences included lack of time synchronisation, varying dimensions, and differing levels of accuracy (see, for example [6]). Such efforts are also aimed at planning safe manoeuvres using the “ship domain” concept when multiple vessels are nearby. These plans generally assume that the manoeuvre will be executed precisely.

The issue discussed here can, in fact, be viewed because of human error on the vessel’s bridge. If the Officer of the Watch (OOW) calculates a safe COG, they must ensure the vessel follows this course. However, the COG is influences by sea currents. To achieve this, simply adjusting the heading (HDT), or the ship’s orientation relative to the north, is insufficient. Doing so requires additional calculations to account for the effect of a current at a particular direction.

Further considerations are carried out with the assumption that the own ship monitors the relative motion of the encountered ship and, on this basis, assesses the movement of the encountered ship and then plans a maneuver to avoid a collision. However, maneuver planning based on data transmitted via AIS can lead to similar effects, if the data relates to the ground. In the context of ASV, interesting conclusions are provided in publications [4]and [11].

2 COLLISION AVOIDANCE BASED ON MOTION VECTOR OVER THE GROUND

As mentioned earlier, the widespread use of the GNSS on a modern vessel and the resulting possibility of automatic data transmission between devices leads to the situation that common practice is to combine a GPS receiver with an ARPA and automatically transmit data about the COG and SOG of the own vessel, which is contrary to the IMO recommendations. For radar image stabilization, such a solution does not raise any objections, but the question arises what impact it may have on the effectiveness of collision avoidance for the work of ARPA or similar devices? The difference between the motion vector relative to the water and the ground is self-evident for mariners. The influence of the wind varies more than the influence of the currents, because it results from the hull structure, the direction of the wind relative to the vessel, and will most likely be different for the own vessel and the vessel encountered. It will also change as a function of the wind direction. On the other hand, we can assume that the movement of water masses within the radius of operation of a typical navigational radar, i.e. within the radius of around 20 nautical miles (NM), will probably be the same for both vessels.

Let us consider what differences will appear in the results of the process of determining the motion vector of the encountered vessel and what impact it may have on the implementation of the maneuver if a GNSS receiver is connected to ARPA as a source of information about the course and speed. Let us assume that the considerations refer to the open sea, so there is no need to take any additional restrictions relevant to maneuvers into account.

This issue can be considered by relating to the motion of both vessels to an Earth coordinate system, but navigators more commonly analyze it by relating the movement of the target to the movement of their own vessel. Of course, one can use analytical relations, as was done e.g. in [18] but in the rest of the article the vector calculus suggested in most navigation textbooks and manuals, e.g. [19] [20], will be used.

Figure 1 shows a typical situation where a target vessel encountered at points A and B was observed within a few minutes, and the analysis of her relative motion suggests that it poses a collision hazard (solid line in red is passing too close to own ship in the center of the radar picture).

In this case, according to COLREG Rule 15, when two power-driven vessels are so positioned relative to each other that there is risk of collision, the vessel which has the other vessel on her starboard side shall keep out the way. On this figure the motion vectors of the own vessel are shown in blue, the sea current vector in green, and the motion vector of the encountered vessel is red. Whereby the solid line represents movement over the ground and the dashed line represents movement through the water. The example confirms the obvious fact that by relating the relative motion of the encountered vessel to the vector of the own vessel over the ground, we will obtain information about the motion of the encountered vessel over the ground, and assuming the own motion through the water, we will receive information about the encountered vessel motion through the water.

Having information about the real motion of the encountered vessel, it is of course possible to plan a collision avoidance maneuver. On this basis we assume that a result of such a maneuver, the motion of the encountered vessel in relation to the own vessel must ensure the appropriate distance of the closest point of approach (CPA) for both vessels. It is not important whether ARPA or any other instrument or method has been used for this purpose. It is important that the result of the maneuver planned in this way is information on what the own vessel's motion vector should be to ensure avoidance of a collision. In other words, if the officer of the watch (OOW) uses ARPA connected to the GPS, he will get information about what COG and SOG will help avoid a collision. Undoubtedly, the situation will look similar on an unmanned vessel when the appropriate automaton performs this task.

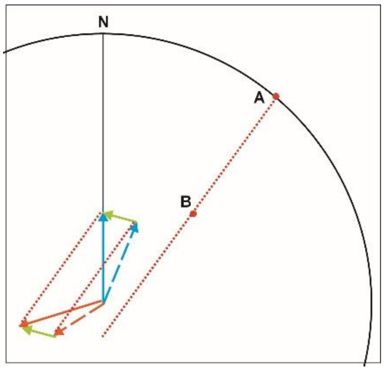

Figure 1. Determination of the motion vector of the vessel encountered.

However, the key question is whether, knowing the value of own SOG and COG, required for avoiding a collision, the OOW or automatic machine will calculate the new STW and the new CTW, considering the current at that moment?

Let us note that in such a case most of OOWs will probably not carry out additional calculations, which is seldom noticed. Most often, OOW will change the course (HDT, not COG) by the number of degrees indicated, usually without changing the speed. It can therefore be assumed that, for example, he decides that a 30-degree turn to starboard should be made by changing the COG, he will in fact to change the course 30 degrees to the starboard by changing the HDT!

Of course, depending on the distance between the ships, the relation between the speed of the own vessel and the target and the speed of the current, as well as the relation between the course of the own vessel, the course of the encountered vessel and the direction of the current, the results of such conduct will be different. It can be assumed that if the speed of the current is small relative to the speed of both vessels, the effect will be small. And if the speed of the current is higher, the impact may be significant. The question arises as to what significant changes this approach causes and where are the limits of acceptability of such a practice?

Taking the problem in general, it would be necessary to consider different proportions of the speed of both vessels and the speed of the current, different courses of vessels and different directions of the current, and sectors in which vessels move relative to each other. This makes the analysis very complex and multifaceted. Therefore, the following section is limited to cases where the own vessel should give way, and its speed and course over the ground are unchanged. It has been assumed that the target and own vessel are both a typical merchant, power driven vessels, and therefore their speed are within 10 to 25 knots. The influence of different current directions at a constant value of its speed, which is up to 50% of the SOG of the own vessel, has been analyzed.

3 RESULTS OF INVESTIGATIONS

The issue under consideration is a function of many factors defining the mutual movement of both ships. It also depends on environmental conditions, such as the extent of the water area (possible restrictions on maneuvers), the direction and strength of the wind and the type of ship. However, I omitted these factors, treating the reported research as a rough examination of the issue. Moreover, considering all the factors would make it difficult to present the results synthetically, and the aim is to estimate how big an impact the analyzed approach has and how complicated it is. The next two figures show a similar case, but the difference is in the direction of the current. This shows how important this information is and how different the results of the maneuver can be.

3.1 *Scenario #1; Target at an Angle of 45o, Sea Current in parallel with own COG*

In Fig. 2 shows a situation when the own vessel must have to give way to a vessel visible from starboard side at a relative bearing of approximately 45°o. It has been assumed that both vessels are affected by a current with a direction consistent with the COG of the own vessel and a speed slightly less than half the SOG of the own vessel. This means that the own vessel's CTW is consistent with the COG and its speed STW is noticeably lower than the SOG. The analysis of the situation suggests that the encountered vessel will pass a short distance astern. This analysis also shows that the safe passing distance (DCPA) will be ensured by a turn to starboard of 25° (Fig.2a, dashes red line). However, to perform such a maneuver, a new heading and perhaps also a new STW should be calculated. Such calculations are generally not carried out on the bridge and most likely a routine turn to the starboard will be made by the mentioned angle of 25° (Fig. 2b vector in blue, dashed line). Such a change of the own course, considering the current, will cause the own vessel to move on the COG of 015°, not 025°, and her SOG will drop. In the consequence they will pass closer than planned (dotted line in red).

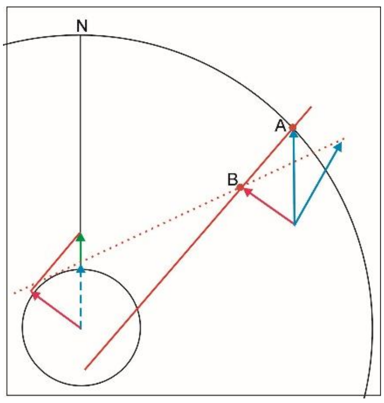

Figure 2a. An illustration of the collision avoidance process: a - planning the maneuver - make a turn to the starboard so that the COG increases by 25°.

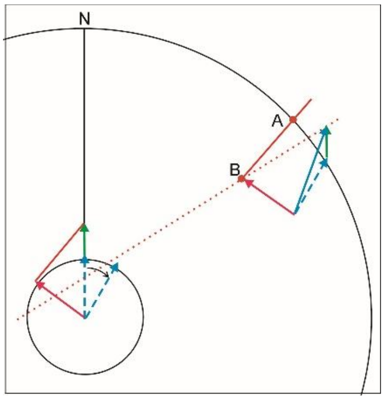

Figure 2b. An illustration of the collision avoidance process: b – starboard turn (HDT) of 25° gives the new COG/SOG but does not give the planned CPA distance.

3.2 *Scenario #2; Target at an Angle of 45o, Sea Current in Parallel the Target's COG*

Let's consider a similar case, assuming the current velocity remains as in the previous example, but its direction is consistent with the target's COG, approximately deflected to the left from its own COG by 45°. Of course, if the course and speed over the ground of the own vessel do not change, this means different parameters of the motion of both the encountered vessel and the own vessel through the water, but since the motion over the ground of both vessels remains the same as in the previous example, a turn to the starboard should be made again to avoid a collision by 25° (Fig.3a), which would require a change in course and possibly speed.

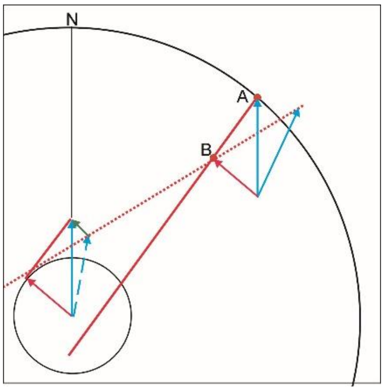

Figure 3a. Illustration of the collision avoidance process when the current direction is in line with the target COG: a - planning maneuver, as the movement of both vessels relative to the ground has not changed (compared the previous case) the planned maneuver requires the same change in COG as be before, although the CTW and STW of the own vessel are different.

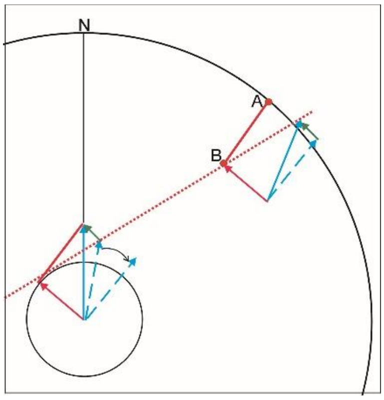

Figure 3b. Illustration of the collision avoidance process when the current direction is in line with the target COG: b - a 25° turn to the starboard from HDT 010o results in a 035° new HDT so resulting in smaller SOG of the own vessel, but accidentally obtains planned DCPA.

3.3 *Scenario #3, Example of the Test Executed on the Simulator*

As was explained earlier, different configurations of ship speeds and currents as well as the relative arrangement of ships were tested in the simulator. However, they all referred to rule 15 of COLREG. One of the variants is described below.

Target vessel is observed at point A, on distance of 8NM. After 6 min the target is at distance of 7NM, so the relative speed of the target is 10kn. The line connecting both points (relative course of the target) is directed to the center of the picture, so exists the risk of the collision. Speed of the current is 10 knots, direction – 090°. If CTW of the own vessel is 340° and STW is 20kn then COG is 010° and SOG 20kn. If the safety distance (DCPA) is taken as 2NM then own vessel should turn 30° to the starboard, however changing heading (not COG!) to the starboard at 30°, the new heading will be 010° and adding up with the vector of the current, the new COG will change into 040°. In these circumstances the relative movement of the target will be differ than expected and DCPA will be lower than 0.5NM.

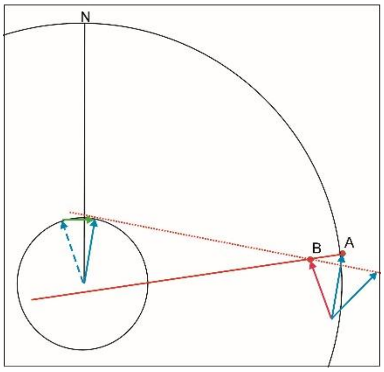

Figure 4a. An illustration of the collision avoidance process when the direction of the current is perpendicular to the own vessel's COG: a - planning maneuver – COG should be changed at 30° to the starboard.

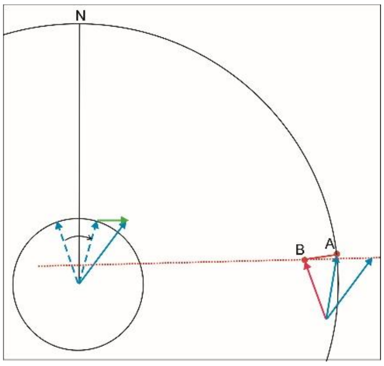

Figure 4b. An illustration of the collision avoidance process when the direction of the current is perpendicular to the own vessel's COG: b – if heading will be changed at 30° to the starboard then new CTW will be 10° and in consequence the new COG = 040°. If so, then DCPA is about 0.5NM only, not according to the plan.

4 DISCUSSION

Similar considerations and experiments as one presented as 3.3 have been carried out for different proportions of own vessel's speed, target and sea current. Different mutual positions of the two vessels were also considered, however, with the assumption that the target was on the starboard side, at distances of 8 or 20NM. Scenarios were composed of 8th cardinal and intercardinal directions of the current in the relation to the own COG with the combinations of the own speed 12, 15 and 20kn and encountered vessel of 8, 12 or 24kn.

The tests have been carried out on the navigation full bridge simulator Navi Trainer 5000 [21] with the use of warship model (frigate) as an own ship and coastal cargo ship and fast cargo seagoing vessel models as encountered vessels. In total 70 scenarios were tested on the open, calm sea and part of them consider moderate wind. Depending on the relative wind direction, the results of some scenarios were different from others, what was expected.

But in general, they show that low current velocities, approximately up to 3 knots, do not cause significant discrepancies in the results of the anti-collision maneuver, what was predicted. This is because for vessels moving at speeds in the range of 10-25 knots, low current does not cause significant differences between the COG and CTW. Therefore, it can be assumed that the low current is not significant for the issues under consideration. However, when the speed of the current exceeds these values, the use of information about the COG and SOG for planning the maneuver and performing it by changing the vessel's heading (in fact CTW, not COG), causes that, in reality the CPA may decrease to zero or increase by 100% compared to the planned value. It depends primarily on the direction of the current in relation to the COG of the own vessel and the relative bearing onto target. The greatest changes occur when the direction of the current is perpendicular to the own ship's COG, and the divergence from plan is directly correlated with current speed.

A synthesis of such considerations is shown in Figure 5, where the changes between the planned DCPA value calculated based on the COG/SOG and implemented by changing the vessel's course are included.

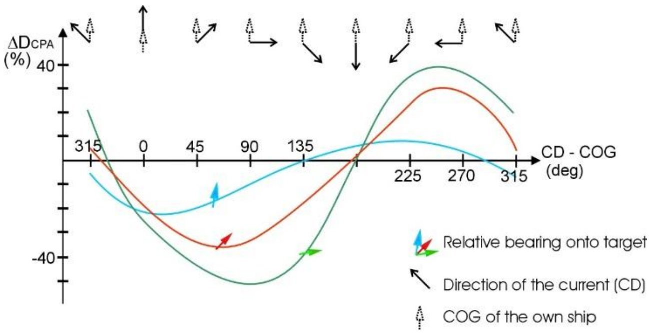

Figure 5. General tendencies in changes of DCPA as a function of the differences between the direction of the current (CD) and COG of the own vessel and the direction to the target. Changes are presented in % of planned DCPA if before the maneuver DCPA is zero.

The three presented curves correspond to three different directions to the target (heading angles) from the own vessel (the heading angle is marked with a colored arrow in the color of the appropriate curve). The values of differences between the planned and actual value of the CPA distance (DCPA) were presented as a function of the angle between direction of the current (DC) and COG of the own vessel and the relative bearing onto encountered vessel. The graph shows the changes when the initial DCPA is zero. The axis showing changes in DCPA (◎DCPA) is scaled as a percentage of planned DCPA. It should be emphasized that this picture is slightly different if the initial DCPA value is not zero. Then the changes are smaller by several percent. The values of these changes depend on the speed of both vessels and the speed of the current, as well as the distance between the vessels at the start of the maneuver and planned DCPA. At this stage of research, only certain trends can be indicated. The impact of individual factors and the correlations between them require further in-depth research. However, there is a clear tendency to change the actual DCPA value in relation to the planned one.

This depends primarily on the direction of the current:

- If the current causes an increase in the speed of the own vessel or when the direction of the current increases the speed of approach of both vessels, the actual passing distance decreases as compared to the planned one,
- The closer the target is to the traverse, the greater these differences are,
- If the direction of the current causes the SOG of the own vessel to decrease, the passing distance does not change significantly,
- If the direction of the current is in the sector 90o from the direction to the target, the actual passing distance decreases, while when these directions are opposite the CPA increases.

Various current speeds have been assumed in the considerations, but not exceeding 10 knots, as in relation to standard vessel speeds, the speed of the current does not exceed the speed of typical vessels. It has been assumed that the speed of both vessels did not differ significantly. The differences between the planned and the actual DCPA differed, sometimes by a factor of two. This confirms the questionable usefulness of the solution considered and highlights the need for careful observation of the effects of the maneuver by the officer of the watch. It can be assumed that if on a manned vessel the officer of the watch (OOW) supervises the maneuver, and if it turns out that there is still a risk of excessive approaching (the maneuver turned out to be unsuccessful), he will simply correct the movement of his vessel. However, in the context of the discussed problem, the risk of collision with unmanned objects is of particular importance.

In this context, apart from the previously considered aspect of using information about the movement relative to the ground, not the water, there is also the aspect of possible differences between the speeds of both vessels. It can be assumed that unmanned transport vessels MASS will move with speed similarly to manned vessels and will most likely be detected at distances like those at which ordinary, manned ships are detected. However, small, unmanned vessels (surface drones) engaged in various research and measurements at sea should be noticed. As a rule, they are small objects, which cause an additional risk of being detected at short distances.

But the more important aspect is their low speed, of the order of a few knots. This means that the speed of the current radically changes the nature of their motion. It should be assumed that such objects will also be equipped with AIS devices, which is one of the reasons for the increasingly common consideration of collision avoidance issues based on movement over the ground, with AIS system. An example of joint use of AIS and ARPA is given, for example, by [10]., however, it may be debatable to equip such an object with radar. Often AIS will be the only source of data for such a maneuver.

In addition, it should be assumed that there may be a tendency to limit the range of navigation systems that these small facilities will be equipped with, so such a drone may not have a speed log. Consequently, it is very likely that information about their movement through the water will be unavailable, and information about their movement will only result from the use of the GNSS, which means information about the movement over the ground. If so, the issue under consideration becomes a burning one.

The adoption of vessel motion parameters relative to the ground (COG, SOG) is inconsistent with the IMO recommendations, however, the negative effects of such an approach are often insignificant. If external factors (mainly current and wind) do not significantly affect the differences between the vector of motion through the water and over the ground, such an approach is acceptable. It also turns out to be a negligible factor when external factors increase the SOG in comparison to STW.

What is most important, in tidal waters, when the current speed exceeds 30% of the own SOG the actual DCPA may vary dramatically from the planned one, and these differences may exceed 100% of the planned DCPA.

This phenomenon also occurs on passenger vessels, ferries and others, which are characterized by a large windage area, although this issue has not been described in the article, the possibility of a similar threat should be considered. This issue requires further investigation.

A separate aspect of the issue is the possibility of anti-collision maneuvering of autonomous surface vehicles, which usually do not have sufficient speeds. So, in tidal waters the drift can be a significant impediment.

Presented studies have the character of the recognition of the problem. Further studies should be concerned on the case of small surface autonomous vessels and short distances of detection, as this cause small value of the distances of closest point of arrival and consequently biggest threat of collision.

5 CONCLUSIONS

In this paper only one, specific aspect of collision avoidance problem has been analysed which is the effect of using the own ship's motion vector over the ground instead of its motion vector through the water as recommended by the IMO.

The basic conclusion is that the use of COG and SOG is permissible at low values of current speed and when the current direction is consistent with or opposite to the own COG. This is especially essential, when encountered vessel is near the traverse of the own ship.

The problem undoubtedly requires deeper investigation, especially with the increasing number of unmanned ships navigating the. The author was unable to find any publications in global literature addressing this topic, which appears to be growing in significance. It would be advisable to conduct research using the ASV model, if this ship avoided collisions. Currently, the author does not possess such a mathematical model which can be used in the simulator. The correlation between the influence of many factors on this issue also requires in-depth research.

Next essential aspect is the lack of the credible knowledge about the influence of the wind on the unmanned ship (especially ASV) and the own ship in the conflict situation. The growing number of small ASV, some of them partially submerged, opens another aspect of this issue, as these small units will be detected at short distances, which may limit the maneuverability of a seagoing vessels. If we assume that ASVs will move with speeds not greater than 10 knots, then the speed of the sea current seems be extremely important factor.

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