

## Verification of navigational decision supporting system on the ECDIS simulator

## Weryfikacja nawigacyjnego systemu wspomaganie decyzji na symulatorze ECDIS

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**Key words:** collision, decision support system, ECDIS

### Abstract

The report presents the results of simulations carried out at the ECDIS laboratory of the Maritime University in Szczecin. Their purpose was to verify the correctness of results obtained from authors' programme, in particular the calculated meeting parameters of vessels and the collision prevention manoeuvre made.

**Słowa kluczowe:** zderzenie, system wspierania decyzji, ECDIS

### Abstrakt

W raporcie przedstawiono wyniki symulacji dokonanych w laboratorium ECDIS w Akademii Morskiej w Szczecinie. Celem było sprawdzenie poprawności wyników otrzymanych z autorskiego programu, w szczególności wskazanie parametrów spotkania statków i manewrów zapobiegających kolizjom.

## Introduction

The basic purpose of conducting navigation is efficient and safe passage of the vessel on an assumed trajectory. Taking this into account the navigational system supporting the making of decisions must perform two basic tasks: the conduct of a vessel on an assumed trajectory and the avoidance of collisions. The purpose of the system prepared is to work out such decision variants for a particular situation which do not collide with the specific character of the area and its restrictions, vessel traffic in the area and the rule-of-the-road regulations in force [1]. It can thus be said that the system should make it possible to:

- estimate a navigational situation,
- indicate alternative decisions,
- indicate only permissible and feasible decisions,
- allow the navigator to assess the decision and introduce additional assumptions.

Taking the above criteria into consideration, an algorithm [2] was worked out for the vessels' meeting situation in good and restricted visibility. On the basis of this algorithm a program was made for calculating a solution to the collision situation.

## Experiment assumptions

The simulation experiment was conducted at the ECDIS Laboratory of the Maritime University of Szczecin. The Navi Trainer navigational manoeuvring simulator by Transas Marine, used in the experiment, is designed for training purposes resulting from STCW 78/95 Convention. The Navi Trainer Professional software works in an integrated network environment based on Windows NT operational system. Radar work simulation appliances, ARPA, ECDIS system, the gyrocompass, the log, GPS receiver and other systems and navigational appliances fulfil all the existing standards accepted by the IMO (International Maritime

Organization) and international conventions. The verification was carried out in the open sea, as the main task was to check the correctness of calculation made by the decision support system without the restrictions of water area geometry and hydro-meteorological conditions.

Figure 1 shows the central processing unit (CPU) of the decision support system. The method of supporting navigational decisions utilizes the processing of digital signals from the following sources: AIS, ARPA, GNSS receivers (e.g. GPS, DGPS), log, gyrocompass, ENC and other navigational systems and devices. The CPU receives signals from all the above mentioned devices and systems. Processed by special computing algorithms, signals are presented to the operator on a display in alphanumeric and graphic form.

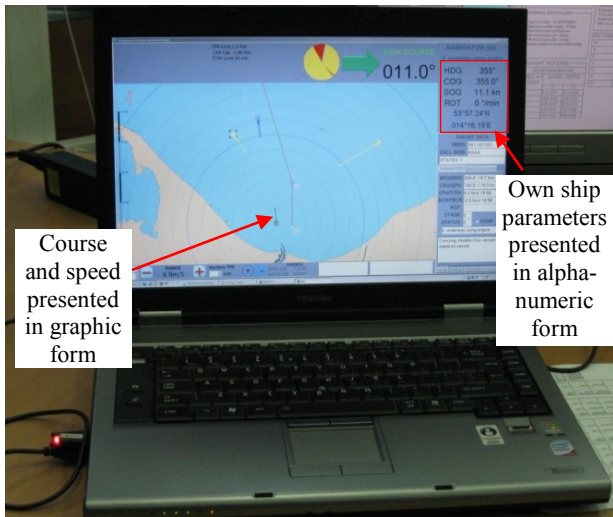


Fig. 1. CPU of the system  
Rys. 1. Jednostka centralna systemu

**Behaviour of the system when own ship does not perform recommended manoeuvres**

Figure 2 presents a projection of the screen on which four vessels are visible against a chart of Pomorska Bay. The southernmost vessel is own ship. On the basis of fixed range rings (with 1 Nm spacing between rings) and the data on vessel 2, presented in the bottom right-hand corner of the screen, one can find out that the distances to target vessels are longer than 8 Nm. According to the assumed guidelines the system recommends maintaining the present course and speed and proceeding to the next waypoint, whose coordinates are given in the top centre of the screen. This recommendation is presented to the navigator in the form of a green vessel shape also placed in the top centre.

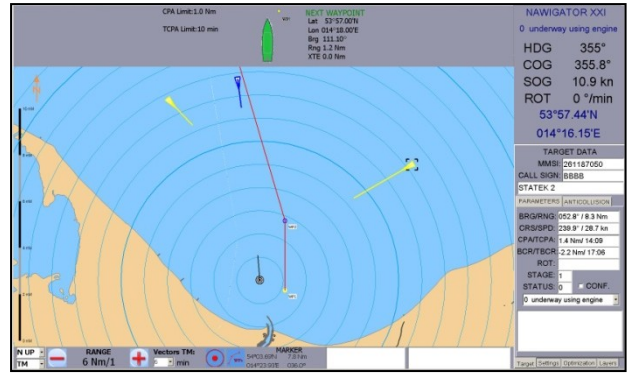


Fig. 2. Initial stage of a vessel encounter  
Rys. 2. Początkowa faza sytuacji spotkania

Figure 3 implies that the range to vessel 2 is 7.1 Nm, therefore this vessel is qualified to stage 2 of the encounter. In compliance with COLREGs, the situation assessment results in qualifying our vessel as a give-way one, as displayed in the bottom right-hand corner of the screen. The calculated CPA is 1.4 Nm and the value is larger than the assumed CPA Limit (screen top). Our vessel does not have to perform a preventive manoeuvre in relation to vessel 2. However, there is no doubt such manoeuvre has to be made relative to the vessel right ahead of us. In this connection the system has developed maximum and recommended manoeuvres in relation to other ships proceeding in a range shorter than the assumed 8 Nm. Allowable course alterations are presented in the form of a coloured circle and marked yellow. The solutions that will end up in passing the other ship at a distance shorter than the preset one are marked red. The recommended solution is shown by the arrow and described as New Course. Numerically displayed is the recommended course (in this case 070.8°).

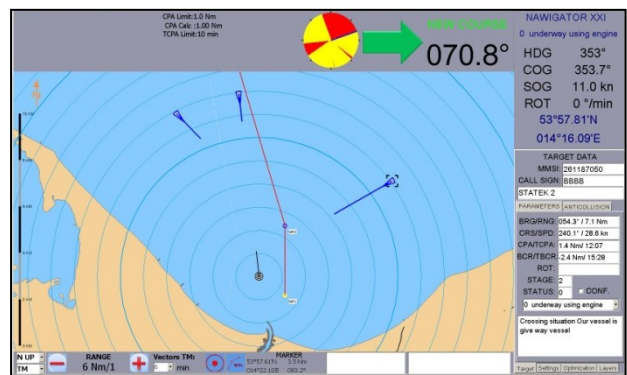


Fig. 3. Presentation of the recommended and allowable manoeuvres  
Rys. 3. Prezentacja zalecanych i dopuszczalnych manewrów

Figure 4 shows other novel solutions. Of the two circles shown, the one at the screen top presents a solution considering all vessels. The other, displayed at the bottom right-hand corner shows

solutions relative to Vessel 2. After modification made by the operator, information on restricted visibility appeared. In such cases relevant provisions of Collisions Regulations are applied.

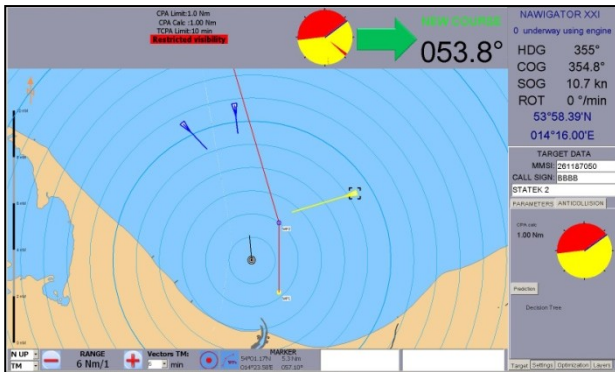


Fig. 4. Restricted visibility  
Rys. 4. Ograniczona widzialność

The system has not found a solution involving course alteration for the situation shown in figure 5 such that the vessels would be able to pass each other at the adopted CPA Limit. Consequently, the system automatically reduced CPA by 50% for which it seeks solutions. This action is displayed at the top screen as CPA Calc.

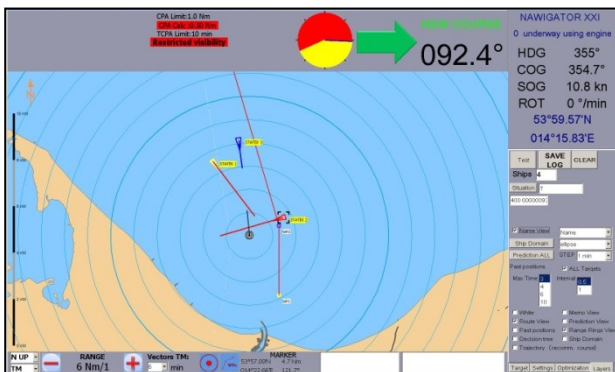


Fig. 5. Reduction of the assumed CPA  
Rys. 5. Zmniejszenie założonego CPA

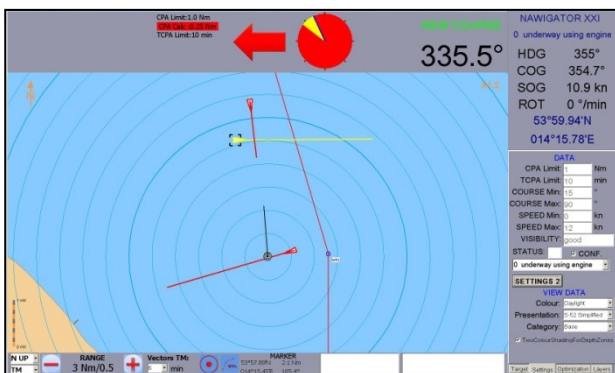


Fig. 6. Solutions for CPA Calc = 0.25 Nm  
Rys. 6. Rozwiązanie dla CPA Calc = 0,25 Nm

If the navigator still fails to perform the manoeuvres recommended by the system, the vessels may come so close to each other that passing at 0.5 Nm will not be possible. The system will again reduce CPA by 50%. Then CPA Calc will be equal to 0.25 Nm. This information will appear at the screen top (Fig. 6).

The further reduction of CPA Calc has not been foreseen as it was concluded that passing another vessel in an open sea area at a range shorter than 0.25 Nm would not be regarded as safe. When the system does not find solutions for 0.25 Nm, there will be a message at the top left-hand corner of the screen that a collision can only be avoided by coordinated actions of both vessels. In such situations the circle with allowable manoeuvres will not appear (Fig. 7).

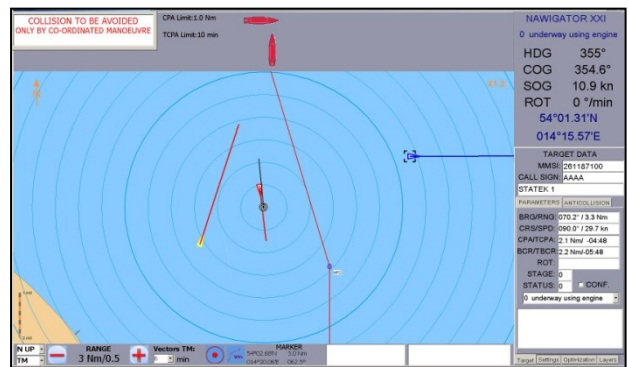


Fig. 7. Information about the close quarters situation  
Rys. 7. Informacja o nadmiernym zbliżeniu

### Behaviour of the system when own ship performs recommended manoeuvres

Figure 8 presents the initial stage of an encounter situation. The southernmost vessel is own ship. According to the assumed guidelines the system recommends maintaining the present course and speed and proceeding to the next waypoint, whose coordinates are given in the top centre of the

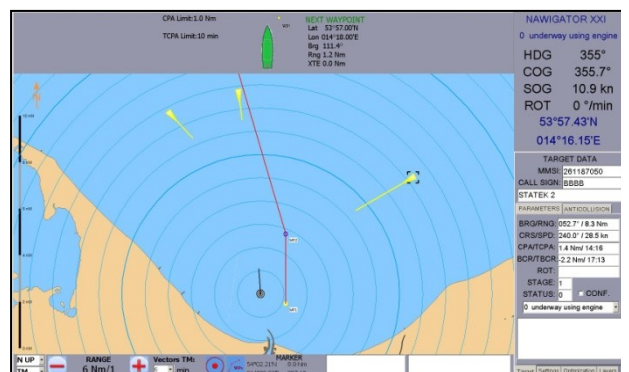


Fig. 8. Initial situation  
Rys. 8. Sytuacja początkowa



screen. This recommendation is presented to the navigator in the form of a green vessel shape also placed in the top centre.

When a distance to any object decreases to less than 8 Nm, the situation including that object will be qualified in compliance with COLREGs. This qualification and indication which of the vessels has the right of way will be shown in the bottom right-hand corner of the screen, right under the radar report (Fig. 9).

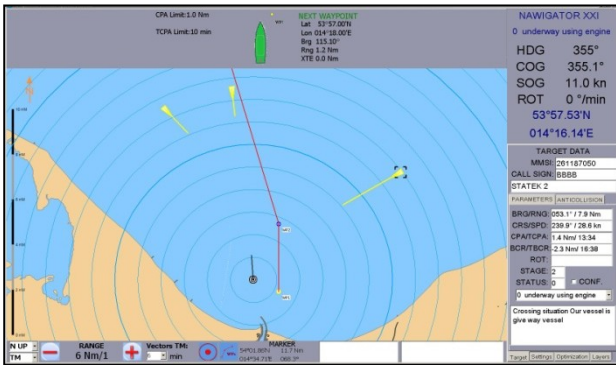


Fig. 9. Qualification of an encounter situation as per COLREGS  
Rys. 9. Kwalifikacja sytuacji spotkania według MPOM

In the case own ship does not have the right of way, as illustrated in figure 9, the system proposes solutions to a collision situation, which make it possible to pass at a preset CPA all the vessels proceeding at a range less than 8 Nm (Fig. 10). The CPA value is given in the top central part of the screen. Besides, at operator's request, the recommended trajectory will be displayed, indicating *inter alia* a moment of completing the manoeuvre and the course leading to the next waypoint (Fig. 11). The Trajectory option is available under the Layers tag in the bottom right-hand screen.

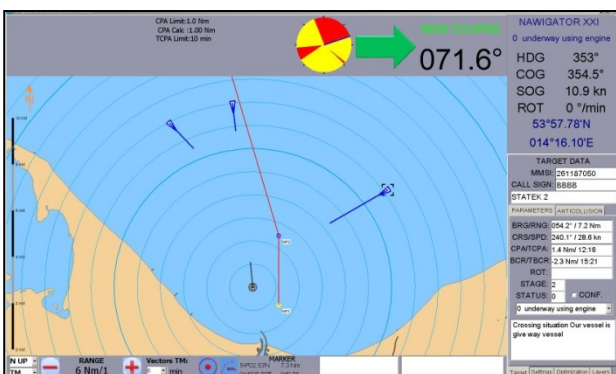


Fig. 10. Presentation of recommended and allowable manoeuvres  
Rys. 10. Prezentacja zalecanych i dopuszczalnych manewrów

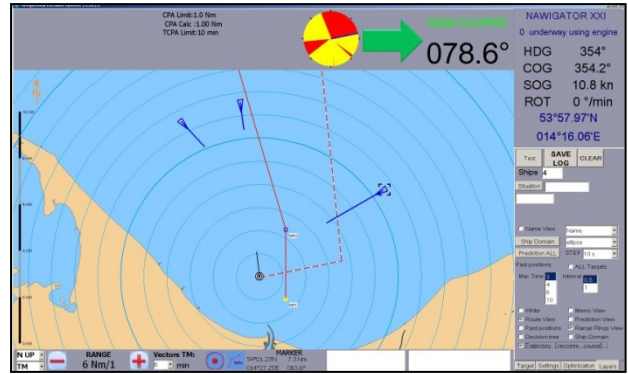


Fig. 11. Recommended trajectory  
Rys. 11. Zalecana trajektoria

After the preventive manoeuvre, with Vessel 2 moving away (Fig. 12), our ship will settle on the course aiming at the next waypoint.

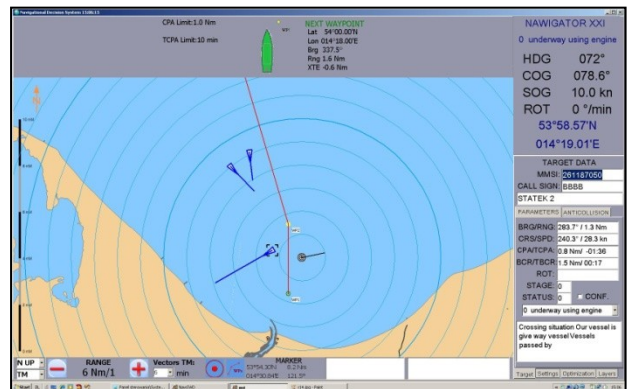


Fig. 12. Situation after passing Vessel 2  
Rys. 12. Sytuacja po rozminięciu z obiektem Statek 2

After a return manoeuvre, the CPA relative to Vessel 1 is 0.6 Nm. The system has qualified the situation as crossing courses and indicated our own ship as the stand-on vessel, which complies with the COLREGs. Therefore, maintaining the present course and speed is recommended (Fig. 13).

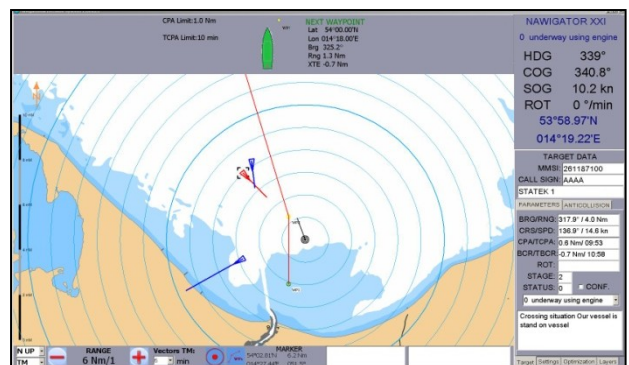


Fig. 13. Situation of encounter with Vessel 1  
Rys. 13. Sytuacja spotkania z obiektem Statek 1

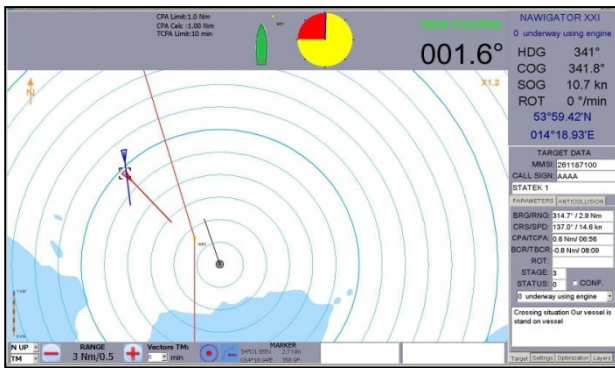


Fig. 14. Proposed solutions in the right-of-way situation  
Rys. 14. Propozycje rozwiązań w sytuacji pierwszeństwa drogi

An analysis of the situation in figure 14 shows that Vessel 1 has not performed a preventive manoeuvre. At the same time the distance between the vessels diminished to 2.9 Nm, which qualified Vessel 1 to Stage 3 of the encounter. According to the assumed guidelines resulting directly from COLREGs, the system has proposed manoeuvres enabling passing at the preset CPA. The proposed solutions have been displayed despite the fact that own ship has the right of way. However, when it becomes obvious that the other vessel does not intend to give way, our ship may perform a manoeuvre to avoid a collision (Rule 17 of COLREGs).

## Summary

The system of decision support presented in this article provides the navigator with all possible solutions of a collision situation and displays proposed trajectories. The manoeuvre developed also takes

into account all vessels currently safe, i.e. those vessels whose present CPA is of higher value than that assumed by the navigator. Besides, such manoeuvre is in accordance with COLREGs accounting for good or restricted visibility.

The proposed solutions are excellently marked and described.

The system can be used onboard ships as an alternative or supplement of existing anti-collision systems.

The VTS operator using this system could promptly receive solutions to collision situations focused on any ship in their coverage area and send it as instruction to be followed by the ships involved.

The system can also be utilized while analyzing actual vessel collisions to:

- indicate solutions that would have resulted in avoiding the collision,
- assess the correctness of decisions actually made by navigators.

## References

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