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Dear readers,

We have just welcomed the year 2015. On this occasion I would like to wish You all the best, may your dreams come true, both, those professional and private ones, excellent health. Let's this Year bring new interesting challenges and new opportunities which will be implemented in a peaceful and friendly atmosphere.

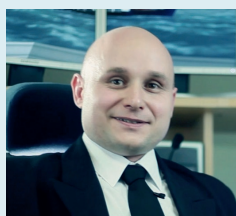
For most of us this is the time for conclusions, plans and changes. This is so in my case. Due to new professional opportunities, after two years of being the editor in chief of EJN I decided to resign from my duty. At the same time I would like to introduce the new editor of EJN Mr Pawel Zalewski, a professor at the Maritime University of Szczecin, who takes over from 1st of February.

I would like to emphasise that those two years became an instructive lesson for me. Thanks to that I got an opportunity to check out myself in a completely new role and to begin the whole publishing process in Poland, under the aegis of Polish Navigation Forum. The beginnings were difficult but since that time, with small technical problems still occurring, we hope that publishing is organized and structured in a good way and EJN itself goes into hands of Mr. Zalewski strong and well-shaped. The last goal we managed to put into practice is the EJN web page, which is to appear online in February.

Saying good bye I would like to thank you all for being with us, for cooperation and understanding and wish you all great time with EJN in the future.

Have a nice reading.
Managing Editor
PhD Arkadiusz Tomczak

New editor biography note



Pawel Zalewski, PhD., DSc., Associate Professor and Director of Full Mission Bridge Simulators (FMBS) Centre in Maritime University of Szczecin (MUS). Born in 1970. In 1994 post graduated Navigational Faculty of MUS achieving Eng. and MSc. degrees and in 2001 PhD in navigation. In home academy he was manager of Navigation Equipment Department in the Institute of Marine Traffic Engineering and later (since 2007) manager and director of Centre of Marine Traffic Engineering comprising FMBS infrastructure. Marine navigator with many years of practical experience at different types of commercial vessels up to chief officer position. In charge and executor of several infrastructural and scientific projects which lead to construction of innovative navigation systems. Specialist in Marine Traffic Engineering, ship simulation and navigation satellite systems. Author of almost 50 papers, 2 monographs and 6 chapters in monographs. Since 2008 member of Polish Navigation Forum and expert of Polish delegation to NAV and NCSR subcommittees to IMO. Since 2011 in charge of DP training centre in MUS accredited by Nautical Institute.



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Towards the assessment of a critical distance between two encountering ships in open waters

key words: collision criterion, near-collision, maritime traffic safety, anti-collision

Abstract

In this paper, we introduce a framework evaluating a critical distance between two encountering ships being on collision courses, at which the collision can be avoided by course alteration of give-way ship alone. This distance is determined with the use of a hydrodynamic model of ship motion, and series of simulations conducted for several types of encounters and predefined two types of ships, namely Ro-Ro and bulk carrier. The framework delivers results in a form of a deterministic critical envelope around a stand-on ship, delineating the area required by the give-way ship to perform collision evasive action.

The concept of MDTC contour is promising and could lead to rising marine traffic safety level by increasing the situational awareness among navigators. Once the concept is fully developed it could be implemented as a part of collision evasive solutions or a part of e-navigation systems, informing the officers about the critical distance and time to commence a successful last chance maneuver.

Introduction

Safety of ship navigation in its widest meaning is a complex issue covering numerous fields, however the anti collision affairs are ranked very high on the importance scale. Therefore, various countermeasures exist to support collision prevention, including training tools (Chauvin, Clostermann, & Hoc, 2009), technology for

maritime surveillance (Bukhari, Tusseyeva, lee, & Kim, 2013) and for integrated navigation support services (Hanninen et al., 2014).

From the operational viewpoint, the most widely used collision avoidance system (CAS) is the Automatic Radar Plotting Aid (ARPA). Also a number of CAS methods have been proposed, in line with developments in e-Navigation (Patraiko, Wake, & Weintrit, 2010). Another solution is based on heuristic criteria categorizing collision risk for various encounters, see for example (Hilgert & Baldauf, 1997). This solution is further refined with fast time simulation techniques by (Schröder-Hinrichs, Baldauf, & Ghirxi, 2011).

From the strategic view point, when the focus is on evaluating the safety over certain sea areas, a concept of ship domain is introduced as a criterion measuring the safety of navigation, for the recent developments see for example (Kao, Lee, Chang, & Ko, 2007; Pietrzykowski & Uriasz, 2009; Wang, 2010). Also fuzzy systems are proposed, as postulated by (Bukhari et al., 2013; Lee & Rhee, 2001; Ren, Mou, Yan, & Zhang, 2011).

However, most of these studies have failed to recognize ship dynamics as a factor affecting the collision criterion. Only a few studies take into account ship dynamics, see for example (Colley, Curtis, & Stockel, 1983; Curtis, 1986; Montewka, Goerlandt, & Kujala, 2012; Zhang, Yan, Chen, Sang, & Zhang, 2012). The model by (Colley et al., 1983) uses concept of maneuvering time, domains and arenas to determine analytically the safe distance for the last chance maneuver. However ship dynamics is implicitly considered in very simplified manner, by calculating the time required for evasive action assuming a fixed rate of turn at a fixed rudder angle of 20 degrees and reaction time of a helmsman.

The model by (Curtis, 1986) considers ship dynamics in order to determinates safe distance for overtaking for one ship type, which is a very large crude carrier (VLCC). The model proposed by (Zhang et al., 2012) estimates minimum required distance for collision evasive action evaluated for one scenario only adopting a simplified model of ship dynamics. In our earlier work (Montewka et al., 2012), we proposed a model that accounts for several ship types and their dynamics as well as wide number of encounter scenarios, however its scope is different from the former models, since it estimates the probability of collision between ships in the high seas.

Therefore there is a need to conduct studies evaluating the reliable and valid criteria for safe ship-ship encounter that can be adopted in operational settings in day-to-day sea navigation, (Goerlandt & Kujala, 2014; Hilgert & Baldauf, 1997), based on the state-of-the art methods and tools.

If the risk of collision exists an appropriate action needs to be undertaken which is defined as course alteration, speed alteration or both, (IMO, 2003). However it is not clearly specified what the due time is. It is understandable, as this parameter depends on numerous factors, both endogenous (e.g. ship characteristics, her maneuverability), and exogenous (e.g. type of encounter, weather conditions).

Therefore in this paper authors introduce a framework evaluating a minimum distance between two encountering ships, at which a give-way vessel is still able to perform evasive action. This critical distance is determined with the use of a hydrodynamic model of ship motion, and series of simulations where conducted for various types of encountering ships under various conditions. The framework delivers result in a form of an envelope around a stand-on ship, which signifies minimum distance at which a collision evasive action can be still performed by a give-way vessel alone by course alteration. Thus, the deterministic contour of a no-go area surrounding the stand-on vessel was established.

Anti-collision application of deterministic approach to MDTC concept


The concept of a minimum distance to collision MDTC was introduced in our earlier works, (Montewka et al., 2012; Montewka, Hinz, Kujala, & Matusiak, 2010) a study leading towards a new definition of a ship\ u2013ship collision criterion, allowing further estimation of the probability of maritime accidents is

conducted. The criterion is called the minimum distance to collision (MDTC). The idea was utilized with regard to statistical data collected from AIS records and it was used for typical ship types and typical encounters characteristic for a specified sailing area. Such solution could be fair applied for the marine traffic engineering analysis aiming at local traffic system assessment with regard to its safety.

In this paper we demonstrate the application of the MDTC concept in the operational setting, aiming at situational awareness increase by informing an officer of the watch of the critical distance between two encountering ships at which a collision evasive action can still be performed by one ship alone. In the presented study, we assume that a give-way ship is the one, which performs the collision evasive action.

Safety of ship navigation is governed by numerous elements and a properly conducted evasive action in ship-ship encounter exists among them. Such an action has to be carried out on time and in line with the existing rules and regulation, such as a convention on collision regulations – COLREGS - issued by the International Maritime Organization. The rules define a list of types of relations between encountering ships and assign appropriate action to be taken in a given situation, which is described in next section of the paper. Although, the general scheme lies on recognizing a give-way vessel (in case of head-on encounter both vessels shall give the way) and monitoring the development of a encounter to assess the effectiveness of a maneuver of this ship. The give-way vessel shall in practice alter her course while the stand-on vessel keeps her course and speed and she shall undertake her own maneuver when it would be clear that the only action of the give-way vessel could not be sufficient. However, for head-on encounters both ships shall alter their courses.

The moment of a decision when the development of an encounter situation becomes dangerous seems to be critical. The negligence related to this decision may lead to close-quarters situation or a collision like for instance in case of car carrier Baltic Ace colliding with the container vessel Corvus J on 5-th of December 2012. The former ship sunk and several crewmembers lost their life. The give-way ship Corvus J did not fulfill her obligation towards the stand-on ship Baltic Ace as prescribed by the Colregs and kept on her course, yet, m/s Baltic Ace was too late with her action to avoid the collision, ("Baltic Ace death toll - Maritime Bulletin," 2012).



Analyzing the commentator's phrase "Baltic Ace was too late with her action" one suspects that the critical distance for reaction in the given encounter was violated. Since, according to the definition of MDTC, the last possible moment for the safe maneuver is just before a give-way ship, which does not fulfill her duties, enters a no-go area covered by the MDTC contour.

The use of the MDTC concept shall consist of calculation, graphic presentation and then direct application of the MDTC as a no-go contour surrounding own vessel, generally being the stand-on vessel. In such a case the officer of the watch could compare in real time the present position of another vessel (give-way vessel) and identify her distance to the MDTC border. Knowing that the MDTC shows the closest approach of ships enabling the so-called last chance maneuver, the officer of the watch would be able to undertake such a maneuver in a time described by the rule 17 of Colreg.

In this paper, an exemplary contour of MDTC was obtained, for selected encounters involving two ship types (RoPax and bulk carrier). This demonstrates the feasibility of the proposed concept as a tool for the situational awareness increase for onboard use.

For this purpose, a set of simulation runs was carried out with the use of a full mission bridge simulator VS-300 at Gdynia Maritime Academy in Poland.

Colreg-based assumptions for collision simulations

According to the rule 11 and subsequent section of the Colreg there are defined three types of ships encounter applied for vessels in sight of one another (IMO, 2003). These are head-on situation, crossing and overtaking. The sketches of these ship-ship relations are presented in Fig. 1-3.

Every vessel, according to the rule 7, shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. Since the collision potential depends mainly on the ship's velocity vectors relation, the risk shall be deemed to exist if the bearing of an approaching vessel does not appreciably change and the distance between two encountering ships gets shorter, (IMO, 2003). This statement is a starting point for every simulation run conducted in the course of this research. In all encounters, according to the rule 8, if there is sufficient sea-room, alteration of course alone may

be the most effective action to avoid a close-quarters situation, (IMO, 2003). Thus such kind of maneuver is conducted in all simulation scenarios.

The action to be conducted by a vessel sailing in risk of collision situation depends on the type of encounter and ship's mutual relation (like presented in Figures 1-3). In case of head-on encounter governed by the rule 14 when two power-driven vessels are meeting on reciprocal or nearly reciprocal courses so as to involve risk of collision each shall alter her course to starboard so that each shall pass on the port side of the other, (IMO, 2003).

In crossing situation described in the rule 15 when two power-driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way and shall, if the circumstances of the case admit, avoid crossing ahead of the other vessel. Moreover, the rule 17 states that the stand-on vessel during first stage of encounter shall keep her course and speed, while according to this rule the give-way vessel shall avoid crossing ahead of the other vessel which is equal to the avoidance to port turns, (IMO, 2003). Thus, the simulation scenarios carried out throughout the presented research do not comprise port turns of any give-way vessel.

According to the rule 13 a vessel shall be deemed to be overtaking when coming up with another vessel from a direction more than 22.5 degrees abaft her beam, that is, in such a position with reference to the vessel she is overtaking, that at night she would be able to see only the stern light of that vessel but neither of her sidelights. In such a situation any vessel overtaking any other shall keep out of the way of the vessel being overtaken, (IMO, 2003). Although there is no exact maneuver recommended the vessel should avoid crossing ahead the overtaken vessel.

The scenarios assumed for the collision simulations should reflect the realistic ship-ship encounters at sea, however one of the main purposes of the study is to evaluate the possibility of estimation of the MDTC envelope. To achieve this the additional assumption is declared. In all considered cases, e.g. head-on, crossing and overtaking the stand-on vessel keeps her course and speed while give-way vessels undertake maneuver to determine the closest approach distance allowing passing by both ships without collision, which is exactly the considered MDTC. All performed near-collision simulation runs aimed at appropriate adjusting the time of maneuver start to achieve the critical distance with regard to ships realistic dynamics.

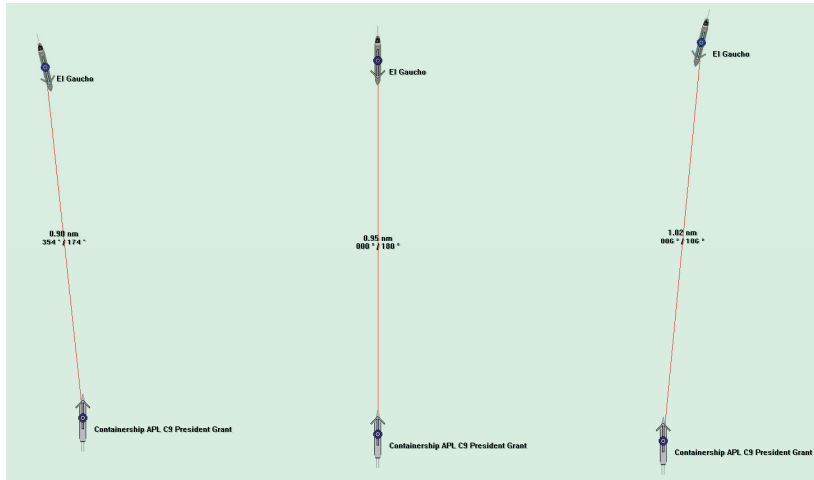


Fig. 1. Head-on type of ship-ship relation (vessels in sight of one another)

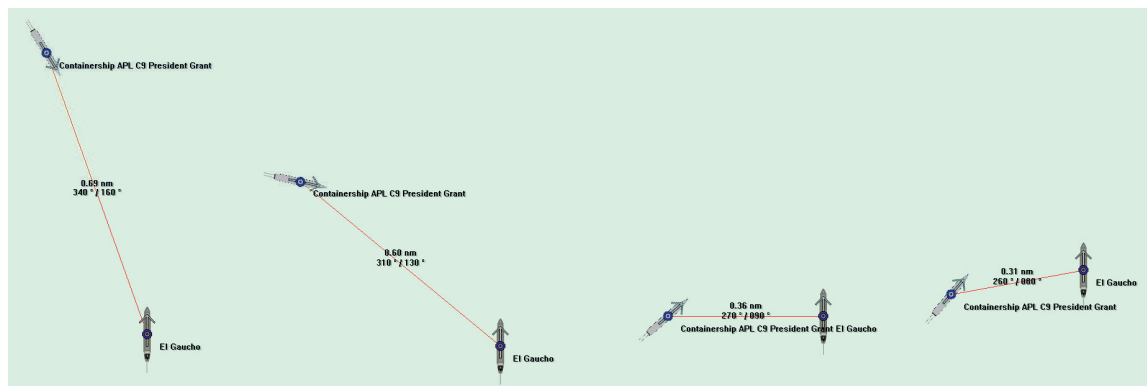


Fig. 2. Crossing type of ship-ship relation (vessels in sight of one another)

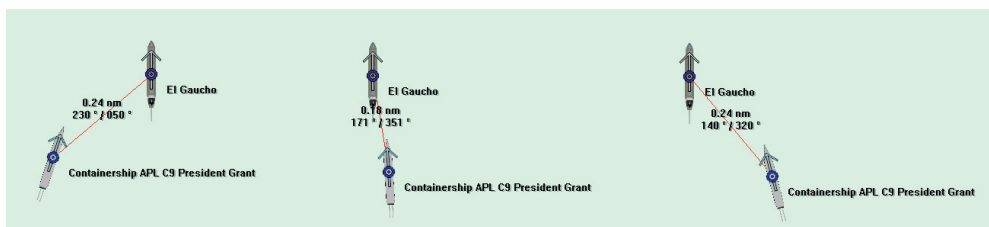


Fig. 3. Overtaking type of ship-ship relation (vessels in sight of one another)

Simulations leading to the estimation of the MDTC contour

Numerous simulations runs were carried out for a pre-defined pair of ships, with the use of bridge simulator, according to the initial assumptions described in previous section of the paper. They were performed for one pair vessels, which particulars are presented in Table 1. The turning circles of two analyzed ships are depicted in Figures 4 and 5.

In the considered cases the stand-on vessel kept her course and speed when proceeding northward and the give-way vessel was maneuvering. First, the simulations were conducted for m/s Norsun being a stand-on

ship, and m/s El Gaucho a give-way vessel. Then, the roles were changed, and another set of simulations was carried out.

The simulations runs were carried out for a wide range of ship relative bearings reflecting head-on encounter, crossing situation and overtaking. The illustrative samples of simulation records are shown in Figures 6-8 for head-on, crossing and overtaking encounters respectively.

The obtained values of MDTC were recorded and plotted in polar coordinates fixed to the stand-on vessel. Thus, a sort of no-go area surrounding the stand-on vessel was created for each considered ship.

Table 1. Particulars of ships utilized in the course of collision simulations

Ship particulars		
Type	Ro-Ro Ferry (Ro-Pax)	Bulk Carrier
Name	Norsun	El Gaucho
Length	169,5 m	225,6 m
Beam	25,0 m	32,2 m
Draft	6,1 m	11,0 m
Displacement	19200 t	66186 t
Service speed	12,7 knt	16,0 knt
Number of propellers	2	1
Propeller type	CRP	FPP
Number of rudders	2	1
Rudder type	spade	horn
Maximum rudder angle	50 deg	35 deg

The turning characteristics of both ships are presented in fig. 4 and fig. 5.

Simulations results

The value of the MDTC obtained in every single case was read from the simulator's operator console and recorded. The full set of such distances obtained for all considered relative bearings between ships, enables preparing a graph surrounding the stand-on ship. In the first analyzed set of scenarios, the Ro-Ro vessel Norsun was the stand-on ship, for which the MDTC contour was plotted, as depicted in Figure 9.

In the second set of simulations, the bulk carrier El Gaucho was the stand-on vessel while the Ro-Ro Norsun was assigned as a give-way vessel. Since, the Ro-Ro vessel is slower than encountered Bulk Carrier El Gaucho, the shape of the MDTC contour differs for the two analyzed simulation sets. For the set two, the risk of collision does not exist between bulk carrier and Ro-Ro ship, when the latter remains in the stern sector of the former. Therefore, there is no MDTC value in the stern sector of the stand-on ship in this case. The resultant contour of the MDTC surrounding

bulk carrier El Gaucho encountering Ro-Ro Norsun is depicted in Figure 10.

The graphs shown in Figures 10 and 11 may be interpreted in close relation to the rule 17 b) governing the situation consisting in excessive approach of a give-way vessel. The rule states that when the vessel required to keep her course and speed finds herself so close that collision cannot be avoided by the action of the give-way vessel alone, she shall take such action as will best aid to avoid collision, (IMO, 2003). The obtained MDTC contour depicts the distance at which the maneuver of the stand-on vessel shall be performed according to the rule 17 b). Thanks to such a presentation of the critical distance the officer of the watch is able unambiguously find out the moment of change of his duties described by the rule 17 b) of Colreg. Officer's consciousness regarding this issue shall lead to better recognizing of an encounter phase and moreover it may facilitate the trial when ships anyway collide.

The quoted rule 17 applies to a crossing situation, however the usefulness of the MDTC concept could be extended to all kind of ships encounters in terms of the assessment of a critical distance to undertake own last chance maneuver. Such a maneuver is not only acceptable in any sort of encounters but also required by Colreg.

Summary and conclusions

The presented research is focused on the deterministic approach to the MDTC concept. A vast number of simulations was carried out according to the definition of MDTC adopted, and the set of admitted assumptions. The authors revealed the feasibility of demarcation of the MDTC contour and its practical presentation.

The analysis of the considered solution reveals some crucial advantages and disadvantages of the proposed concept. First of all the simplicity of the resultant graph and its understanding for every navigator serving as

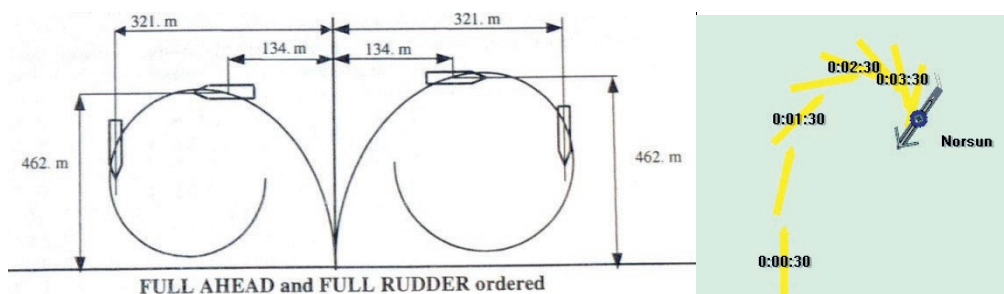


Fig. 4. Turning characteristics of Ro-Pax Norsun

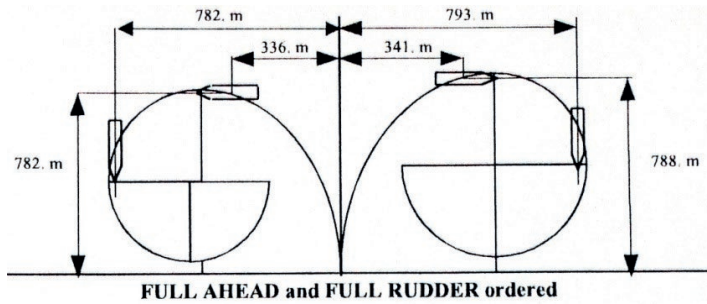


Fig. 5. Turning characteristics of Bulk Carrier El Gaucho

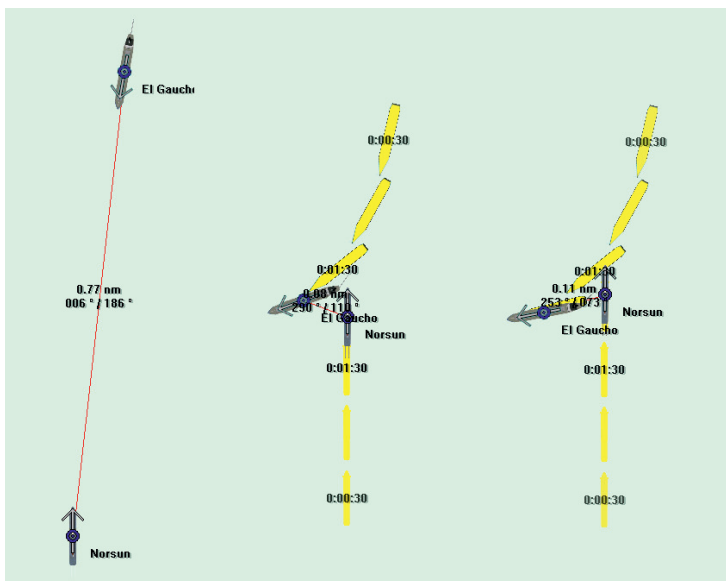


Fig. 6. Sample record of maneuver simulation for head-on encounter

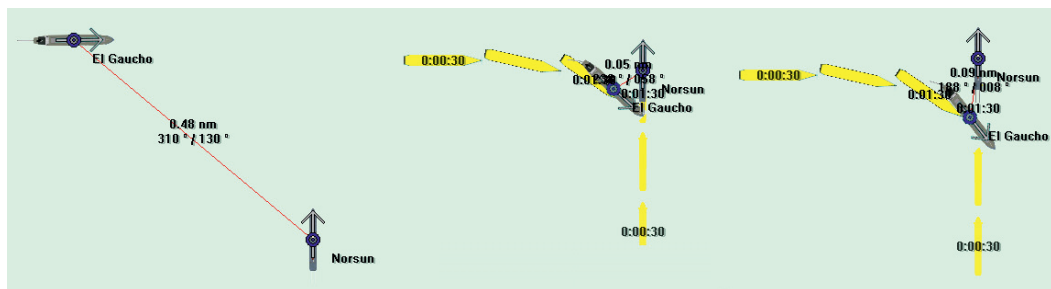


Fig. 7. Sample record of maneuver simulation for crossing situation

an officer onboard are key points to a potential future implementation of the MDTC-based decision support tools onboard ships.

However, the Colreg-based construction of the MDTC contour is based on the rule 17 b) and takes into consideration the maneuvering characteristics of the give way vessels only. Although the geometric extend (in terms of their length and breadth) of both ships are taken into account and their velocity vectors as well, while the dynamics of the stand-on vessel is omitted at all. This leads to the potentially dangerous situation when the stand-on vessel would wait with her maneuver until the

give way vessel comes quite close to the MDTC contour. If the stand-on ship is much larger than the give way one, the distance may be too close to successfully avoid the collision by the sole maneuver of the stand-on vessel. Thus, the modified concept of the MDTC taking into account the dynamics of an own vessel (the stand-on one) is the next planned stage of the research.

Once the concept is fully developed and the dynamics of both encountering ships is accounted for, an officer of the watch would be informed about the critical distance and time to commence a successful last chance maneuver.

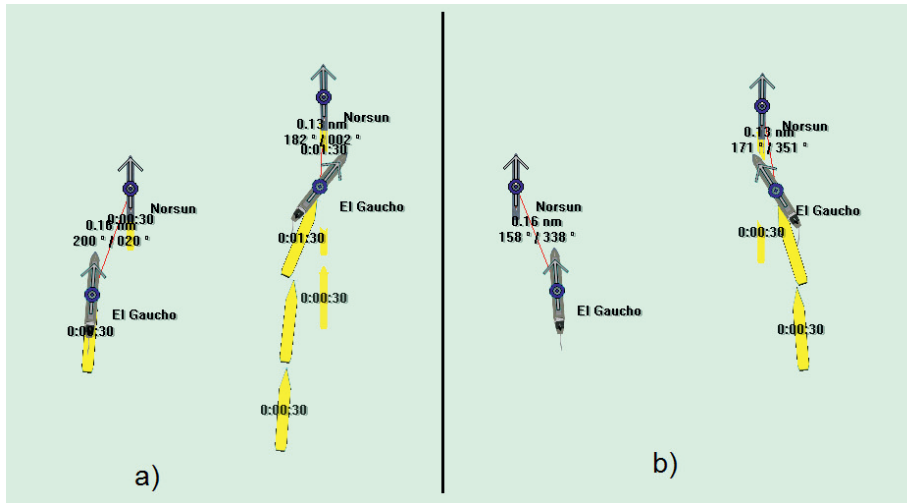


Fig. 8. Sample record of maneuver simulation for overtaking encounter (two exemplary cases)

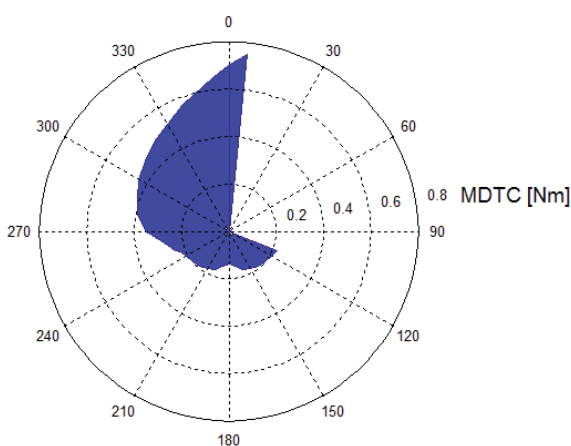


Fig. 9. Graphic presentation of the MDTC as a no-go area surrounding the Ro-Ro vessel Norsun countering the Bulk Carrier El Gaucho which is the give-way vessel in considered case (direction 0 at the graph reflects own ship's bow)

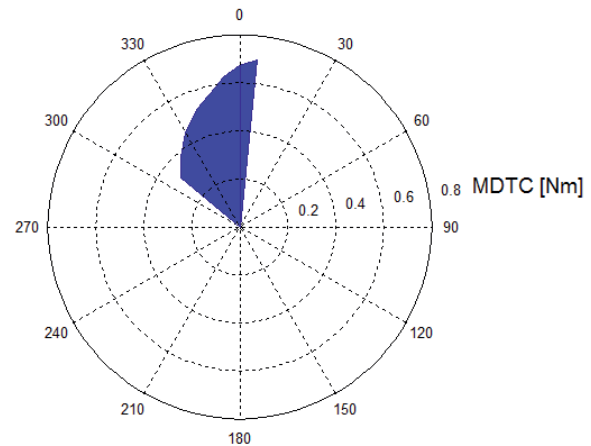


Fig. 10. Graphic presentation of the MDTC as a no-go area surrounding the Bulk Carrier El Gaucho countering the Ro-Ro vessel Norsun being the give-way vessel in considered case (direction 0 at the graph reflects own ship's bow)

The concept of MDTC contour is promising with such an application and could lead to rising marine traffic safety level by increasing the situational awareness among navigators.

References

- [1] Baltic Ace death toll - Maritime Bulletin. (2012). Retrieved December 07, 2014, from <http://www.odin.tc/news/read.asp?articleID=1605>
- [2] Bukhari, A. C., Tusseyeva, I., Lee, B.-G., & Kim, Y.-G. (2013). An intelligent real-time multi-vessel collision risk assessment system from VTS view point based on fuzzy inference system. *Expert Systems with Applications*, 40(4), 1220–1230. doi:10.1016/j.eswa.2012.08.016
- [3] Chauvin, C., Clostermann, J.-P., & Hoc, J.-M. (2009). Impact of training programs on decision-making and situation awareness of trainee watch officers. *Safety Science*, 47(9), 1222–1231. doi:10.1016/j.ssci.2009.03.008
- [4] Colley, B. A., Curtis, R. G., & Stockel, C. T. (1983). Manoeuvring Times, Domains and Arenas. *The Journal of Navigation*, 36(02), 324–328. doi:10.1017/S0373463300025030
- [5] Curtis, R. (1986). A ship collision model for overtaking. *The Journal of the Operational Research Society*, 37(4), 397–406.
- [6] Goerlandt, F., & Kujala, P. (2014). On the reliability and validity of ship-ship collision risk analysis in light of different perspectives on risk. *Safety Science*, 62, 348–365.
- [7] Hanninen, M., Mazaheri, A., Kujala, P., Montewka, J., Laaksonen, P., Salmiovirta, M., & Klang, M. (2014). Expert elicitation of a navigation service implementation effects on ship groundings and collisions in the Gulf of Finland. *Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability*, 228(1), 19–28. doi:10.1177/1748006X13494533
- [8] Hilgert, H., & Baldauf, M. (1997). A common risk model for the assessment of encounter situations on board ships. *Deutsche*

- Hydrographische Zeitschrift, 49(4), 531–542. doi:10.1007/BF02764347
- [9] IMO. (2003). COLREG: Convention on the International Regulations for Preventing Collisions at Sea, 1972 (p. 45). International Maritime Organization.
- [10] Kao, S.-L., Lee, K.-T., Chang, K.-Y., & Ko, M.-D. (2007). A Fuzzy Logic Method for Collision Avoidance in Vessel Traffic Service. *Journal of Navigation*, 60(1), 17–31.
- [11] Lee, H.-J., & Rhee, K. P. (2001). Development of collision avoidance system by using expert system and research algorithm. *International Shipbuilding Progress*, 48(3), 197–212.
- [12] Montewka, J., Goerlandt, F., & Kujala, P. (2012). Determination of collision criteria and causation factors appropriate to a model for estimating the probability of maritime accidents. *Ocean Engineering*, 40, 50–61. doi:10.1016/j.oceaneng.2011.12.006
- [13] Montewka, J., Hinz, T., Kujala, P., & Matusiak, J. (2010). Probability modelling of vessel collisions. *Reliability Engineering & System Safety*, 95(5), 573–589. doi:10.1016/j.res.2010.01.009
- [14] Patraiko, D., Wake, P., & Weintrit, A. (2010). e-Navigation and the Human Element. *TransNav, International Journal on Marine Navigation and Safety Od Sea Transportation*, 4(1), 11–16.
- [15] Pietrzykowski, Z., & Uriasz, J. (2009). The Ship Domain – A Criterion of Navigational Safety Assessment in an Open Sea Area. *Journal of Navigation*, 62(01), 93. doi:10.1017/S0373463308005018
- [16] Ren, Y., Mou, J., Yan, Q., & Zhang, F. (2011). Study on Assessing Dynamic Risk of Ship Collision (ASCE). In *International Conference on Transportation Information and Safety* (pp. 2751–2757). ASCE.
- [17] Schröder-Hinrichs, J. U., Baldauf, M., & Ghirxi, K. T. (2011). Accident investigation reporting deficiencies related to organizational factors in machinery space fires and explosions. *Accident Analysis & Prevention*, 43(3), 1187–1196. doi:10.1016/j.aap.2010.12.033
- [18] Wang, N. (2010). An Intelligent Spatial Collision Risk Based on the Quaternion Ship Domain. *Journal of Navigation*, 63(04), 733–749. doi:10.1017/S0373463310000202
- [19] Zhang, J., Yan, X., Chen, X., Sang, L., & Zhang, D. (2012). A novel approach for assistance with anti-collision decision making based on the International Regulations for Preventing Collisions at Sea. *Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment*, 226(3), 250–259. doi:10.1177/1475090211434869

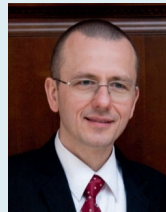
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