TRANSNAV International Journal on Marine Navigation and Safety of Sea Transportation
Volume 3 Number 3 September 2009

The Display Mode for Choosing the Manoeuvre for Collision Avoidance

L. Vagushchenko & A. Vagushchenko
Odessa National Maritime Academy, Odessa, Ukraine

ABSTRACT: The display mode is intended for facilitation of building strategies for collision avoidance by so-called B-manoeuvres. It can be used in ECDIS, ARPA and the simulator systems. B-manoeuvre includes the segment of deviation at a certain angle from the initial course and at the end of it the segment parallel to the initial way's line (planned route). The offered mode is based on the use of forbidden domains for B-manoeuvres. These domains allow choosing parameters and beginning moment of B-manoeuvre for collision avoidance with one or a few vessels. The account of presence of navigation hazards at the choice of B-manoeuvre is produced by setting the borders of maximum lateral shifting from planned route. The offered mode enables visual drafting of strategies for collision avoidance with vessels by successive B-manoeuvres. It is possible to use this mode as basis of computer search of strategies for collisions avoidance with a few targets.

1 INTRODUCTION

Forming of a model of environment is one of major tasks of the control systems. This model must adequately reflect an environment, to provide the high level of understanding of situations and serve as a substantial auxiliary mean at the search of decisions. Choosing one such model of environment for different situations of vessels interaction is difficult, because belonging of elements of environment and properties of operating ship to the categories «substantial», «unimportant» changes in them. It is also difficult to get the universal method of decision for preventing collisions. It is better to determine the environment model and methods of decisions as it applies to different situations. Then the choice of strategies of conduct will be simpler, and they − more precise. Therefore the local problem of development mode for presentation situation of vessels interaction and choosing an effective B-manoeuvre for collision avoidance and passing at a safe distance of targets was set.

2 FORBIDDEN DOMAIN FOR B-MANOEUVRE FORMING

It is accepted, that the alterations of course of operating ship are instantaneous. At such condition a B-manoeuvre looks like shown on a Figure 1, where K − planned course of operating ship; θ − angle of it alteration; Y − lateral distance from initial line of way to the operating ship at the end of deviation; S − length of deviation segment; C_H и C_K − points of course alteration. Course for deviation to starboard (K+θ) is designated K_S, to port (K-θ) − as K_P. An angle θ for collisions avoidance can undertake from 20^0 to 150^0, and for returning to the initial line of way after passing vessels − from 10^0 to 45^0.

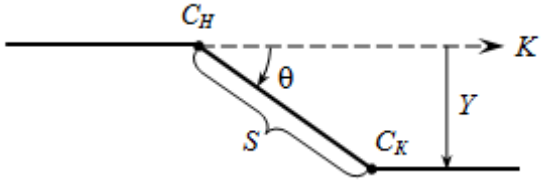

Figure 1. Parameters of B-manoeuvre

Current positions of operating ship and scanned vessel (target) is shown below on Figure 2 by points C and Z. Taking into account presents of navigational hazards and necessity to determine only dander targets within navigable area the zone of manoeuvres and motion (ZMM) of operating ship is set (maximum allowable track margin for current leg). It is determined by width (Y_{DS}, Y_{DP}) of starboard and port lanes for shifting of operating ship at B-manoeuvres.

Beginning of lane of possible shifting to starboard forms a segment CQ on the course $K_S=K+\theta_S$

(Fig. 2), where θ_S = set alteration of initial course for B-manoeuvres to starboard. The butt end segment of port lane is directed parallel a course K_P=K-θ_P (θ_P = set alteration of initial course to port). The values of θ_S and θ_P can be both identical and different. The current position C of operating ship is considered as the appointed element of both lanes.

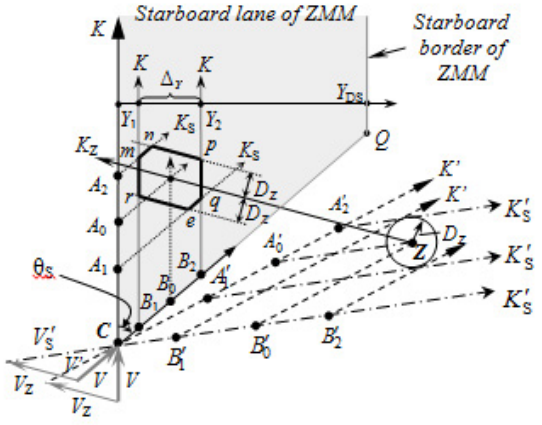

Figure 2. Principle of construction of forbidden domain

Principle of construction of forbidden domain (FD) is characterized in starboard lane on a Figure 2 (Vagushchenko, A.L. 2008), where

K, V = planned course and speed of operating ship;

K_Z, V_Z = course and speed of target;

K' и V', K'_S и V'_S = course and speed of operating ship in relation to a target at true courses K, K_S of operating ship;

D_Z = safe limit of distance between ships;

A_1, A_2 = points of turn from a course K to the course K_S for passing a target at distance D_Z;

B_1, B_2 = points of returning from a course K_S to the former course K for passing a target at distance D_Z;

mnpqer = forbidden domain;

O, A_0, B_0 = the FD center and points of turn from a course K to the course K_S and returning from a course K_S to the former course K for CPA=0;

A'_0, A'_1, A'_2 and B'_0, B'_1, B'_2 = points on the lines of relative motion of operating ship, proper to the points A_0, A_1, A_2 and B_0, B_1, B_2;

Δ_Y – interval of lateral deviations from the planned way which provide close-quarters situation with a target at B-manoeuvres.

Distances S_{AJ} and S_{BJ} (J=0, 1, 2) from a current place C of operating ship to the points A_0, A_1, A_2 and B_0, B_1, B_2 are determined on intervals of time t_{AJ} and t_{BJ} for arrival in these points. These intervals are calculated by values of S'_{AJ} and S'_{BJ} (CA'_0, CA'_1, CA'_2 and CB'_0, CB'_1, CB'_2) and V', V'_S:

$$t_{AJ} = S'_{AJ} / V'$$

$$t_{BJ} = S'_{BJ} / V'_S$$

$$S_{AJ} = V \cdot t_{AJ}$$

$$S_{BJ} = V \cdot t_{BJ}\,.$$

3 USE THE DISPLAY MODE FOR CHOOSING MANOEUVRES FOR COLLISION AVOIDANCE

The category of targets is determined on the location FD in relation to the ZMM borders (Fig. 3). If a target by transponder AIS reported the way points of the route or informed about the set manoeuvre, then an operating ship gets FD of this target taking into account accepted information (target 5, Fig. 3). The probability of possible maneuvering of danger or obstacle vessels can be determined by the expert system (not presented in this paper). In this case the mode of situation can be added with the second FD for this target, proper to possible new course (target 1, Fig. 3). These two FD of target 1 allow forming the incorporated forbidden domain taking into account a possible manoeuvre of target.

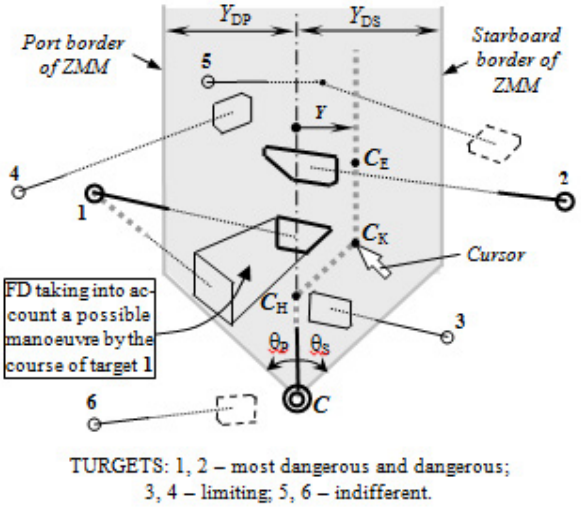

Fig. 3. Situation presentation scheme

The B-manoeuvre for collision avoidance is determined visually on the reflection situation on the screen. The B-manoeuvre is set by pointing the cursor, for example, on point C_K. The trajectory of future motion of operating ship would not cross the forbidden domains. Point C_E marked the end of B-manoeuvre, after which a dangerous ship can be considered finally passed. By a criterion for the choice of B-manoeuvre it is possible to take minimum distance of shifting (Y) from the planned line on condition that the degree of risk of collision with all targets will not exceed the legitimate value at the point C_E and manoeuvre will not conflict with

ColRegs.

The next action is then planned. Depending on the circumstances one of three actions of operating vessel gets out after the first B-manoeuvre: motion along a new line parallel to the planned line (Fig. 4,a); returning on the planned line by B-manoeuvre (Fig. 4,b); proceeding by the course to next way point (Fig. 4,c). The borders of ZMM can be corrected accordingly, if necessary.

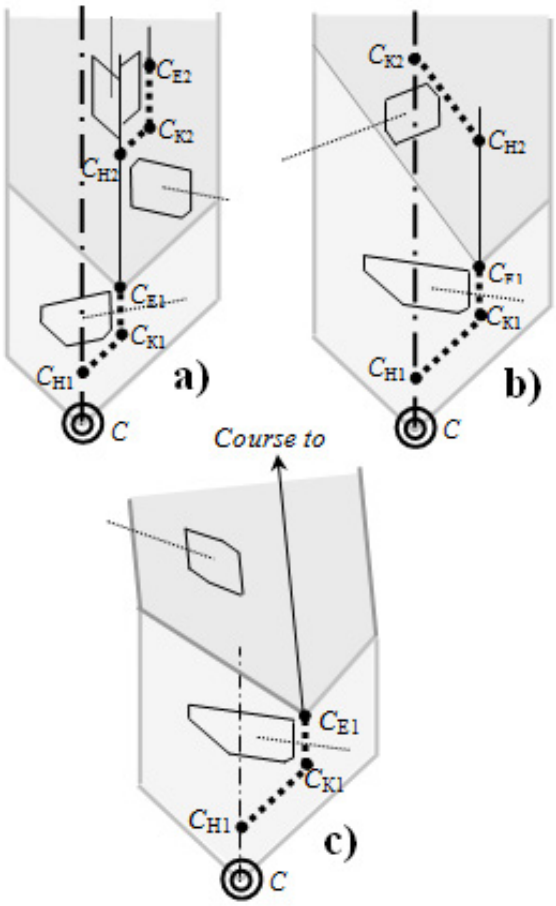

Figure 4. Variants of conduct after the first B-manoeuvre

After this the point C_{E1} is undertaken as appointted element for new ZMM. In this ZMM forbidden domains are determined on the prognosis of motion of operating ship and targets. Similar to finding the first manoeuvre, the second and the following ones are planned, if necessary. The point C_{EJ} determines ZMM until operating ship will not come to this point, whereupon the current position of operating ship becomes the appointed element of this zone.

While searching B-manoeuvres at the beginning by default the values θ_S and θ_P are undertaken as the best from point of providing as noticeable a manoeuvre and prevention of losses of underway time ($\theta \approx 35^0$). When returning to the former line after deviation (Fig. 4,b), the value θ can be taken less.

If it appears that at the chosen values of parameters θ_S, θ_P, D_Z a safe manoeuvre does not exist, it is searched with other values -values of parameters θ_S, θ_P at the search are increased, and a value of parameter D_Z is decrease till the least allows value.

4 CONCLUSION

The offered mode for situations presentation simplifies the choice of manoeuvres by a course change for collision avoidance with a few vessels in open sea and in the confined waters. Advantages of this mode are:

- immobility of the domains in relation to ground, that allows to define manoeuvres for collision avoidance with mobile objects as with immobile;
- simplicity of account of navigation hazards by setting the borders of lateral shifting from planned way;
- possibility to form a strategy for collisions avoidance with a few targets by successive B-manoeuvres;
- possibility to use this mode as basis of computer search of strategies for collision avoidance in any situations.

REFERENCES

Vagushchenko, A.L. 2008. Perfection of methods for operative correction of ship's route. The candidate's thesis on special field of study 05.22.13 – Navigation and traffic control. Odessa national maritime academy, Odessa.