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THE PROBABILITY OF COLLISION DURING OVERTAKING IN THE FAIRWAY

ABSTRACT

The distance when ship starts overtaking manoeuvre in restricted area is one of the basic criteria for safety assessment. The paper presents the results of researches, expert's opinion and initial analysis to access the probability of collision during overtaking in the fairway.

Keywords: Ships Collision, Fairway Traffic.

INTRODUCTION

Navigation when carried out in restricted areas causes a reduction in the vessel's safety level. The navigator, watch officer should take into consideration the factors which have influence on it. These limits are divided into groups [4]:

1. external factors
   – traffic, position of other vessels (different types and particulars),
   – speed of other vessels,
   – the fairway's parameters (breadth, depth, length),
   – hydro-meteorological conditions (wind, wave, visibility, state of sea),
   – day time,
2. internal factors
   – own vessel (manoeuvre characteristics, size of the ship – length, draft, speed, breadth, loading or ballast condition),
   – navigational equipment of own vessel,
   – overtaken vessel particulars (course, speed, size of the ship – length, breadth, draught),

3. human factor
   – experience,
   – education, knowledge,
   – stress,
   – hours of work – exhaust.

The ship carrying out navigation in the restricted area is permanently availability to take a manoeuvre to secure proceeding the route safely. The occurrence of random event „collision with another ship" is pointed by ARPA. The watch officer is making a subjective assessment of the overtaking distance D and time of making a manoeuvre decision in accordance with his own knowledge, experience and distraction factors. Due to the lack of precisely information, that aids the navigator in making decisions in restricted areas, received from navigational equipment (ARPA), anticollision manoeuvers should be supported by other advisory systems, which show the critical area around the overtaken object.

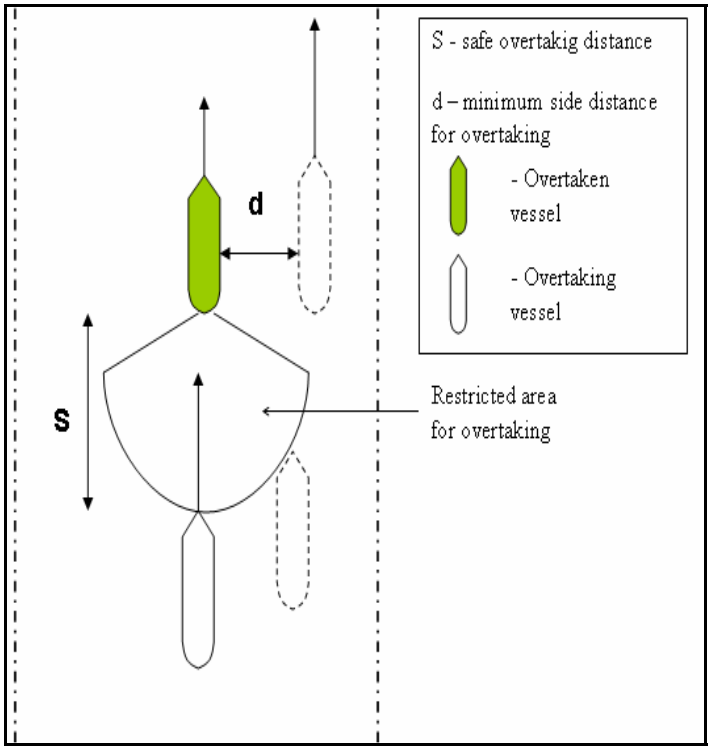

Fig.1. Restricted area and safe overtaking distance S for manoeuvre

In practice the watch officer while assessing the critical overtaking distance, depends on his own knowledge and intuition.

DETERMINATION OF SAFE DISTANCE FOR OVERTAKING USING TRAINING MODELS AND OPINION POLL

The ship carrying out navigation in the restricted areas should be in availability to make an overtaking manoeuvre. When random event occurs – collision with another object, it determines the decision of taking manoeuvre. That decision should result in overtaking object and keeping in the fairway. Therefore it is essential to determine the limits of permissible actions and moments to execute them. The research carried out on the training models (tanker models) made it possible to determine the critical overtaking distance. The models taken into consideration were moving with different speed (11,7 and 3,7 knots). Due to the taken researches, the results presenting dependence between overtaking distance S and rudder angle were received.

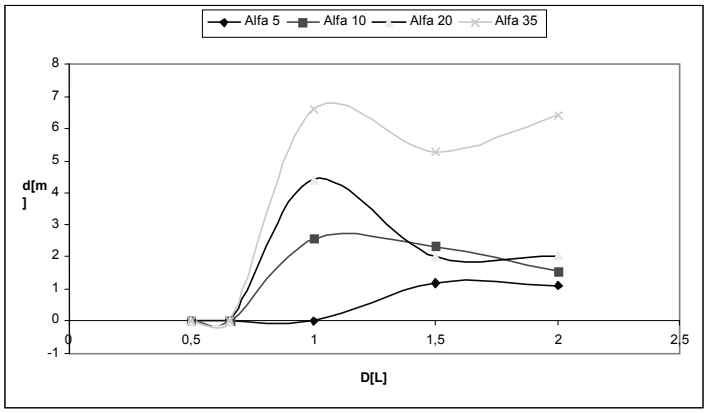

Fig.2. Minimum side distance d depending on safe overtaking distance D and rudder angle α

The results make it possible to determine the restricted area. When it is crossed due to incorrect manoeuvre, the ship will either cause a collision with an object or will avoid the collision between ships but in the same time it will cross out the fairway, traffic separation scheme. The size of the area, and also the critical overtaking distance, will depend on the relative speed of ships and the kind of manoeuvre.

That researches were compared with results received from an expert opinion. The questions concerned vessels/models that were used during researches on training models. The officers had to answer questions about the same overtaking manoeuvre (distance to commence overtaking) as were done on the training models. The probability of collision is based on results of the expert opinion.

THE PROBABILITY OF COLLISION

The probability of having collision can be expressed as the product of P_o and P_f , where P_o is the probability of a overtaken vessel becoming an obstacle, P_f is the probability of the overtaking vessel's failure to avoid collision. To model the probability of the overtaking vessel's failure to avoid collision, two concepts are considered: Available Manoeuvering Distance (AMD) and Needed Manoeuvering Distance (NMD). AMD refers to the actual distance available for the watch officer to avoid collision with overtaken vessel. NMD refers to the minimum (critical) distance that watch officer needs to avoid a collision. If NMD is greater than AMD, vessels cannot avoid a collision.

In this study, it was assumed that both the AMD and NMD are Weibull distributed.

The probability P_f is expressed as P_f =P(AMD<NMD). The probability distributions for AMD and NMD are assumed as follows:

$$AMD = f(D_\alpha, \theta, \alpha) = \alpha\theta^\alpha D^{\alpha-1} e^{-(\theta D_\alpha)^\alpha} \text{ for } \alpha>0,\ \theta>0,\ D>0, \quad (1)$$

$$NMD = f(D_n, \lambda, \alpha) = \alpha\theta\lambda^\alpha D^{\alpha-1} e^{-(\lambda D_\alpha)^\alpha} \text{ for } \alpha>0,\ \theta>0,\ D>0, \quad (2)$$

The shape parameter, α, is the same for both AMD and NMD. AMD and NMT are independent maneuvering distances. The watch officer probability of failure to avoid collision can be calculated as [3],

$$P_f = P(NMD>AMD) = \int_0^\infty \int_{t_\alpha}^\infty f(D_n, \lambda, \alpha) f(D_\alpha, \theta, \alpha) dD_n dD_\alpha,$$

$$= \int_0^\infty e^{-(\lambda D_\alpha)^\alpha} \alpha\theta^\alpha D_\alpha^{\alpha-1} e^{-(\theta D_\alpha)^\alpha} dD_\alpha, = \int_0^\infty \alpha\theta^\alpha D_\alpha^{\alpha-1} e^{-(\lambda^\alpha+\theta^\alpha)D_\alpha^\alpha} dD_\alpha, = \frac{1}{1+\left(\frac{\lambda}{\alpha}\right)^\alpha}. \quad (3)$$

CONCLUSIONS

The determination of the permissible maneuvering area (dependent on critical overtaking distance) will make it possible to overtaking safely another ship being on i.e. the fairway. This area will also inform the navigator about the minimum distance that the overtaking ship is able to approach to execute the manoeuvre, when limit factors are considered.

The knowledge, experience of officers is not sufficient to evaluate Needed Manoeuvering Distance to overtake another vessel in restricted area. The results from an expert opinion show that NMD given by officers are bigger then NMD received from the researches on the training models. The probability of collision presented in the paper gives the possibility to take into consideration the human factor.

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