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Integrated method of navigational risk assessment: a case study in Thi Vai approach channel

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ABSTRACT

1. PROJECT DESCRIPTION

Thi Vai channel is the most heavily trafficked waterway in the South of Viet Nam. Vessels calling ports of Sai Gon area and Phu My industry zone shall pass through Cai Mep and Thi Vai rivers. The total length this channel is 45 nautical miles from Buoy No.0 to Thi Vai Port area, which include a lot of curves and cross leakages along the channel. These rivers are not wide enough but the depth is rather deep and stable against siltation. Therefore this channel has been used in its natural state for long time. General layout of the channel can be seen in Figure 1.

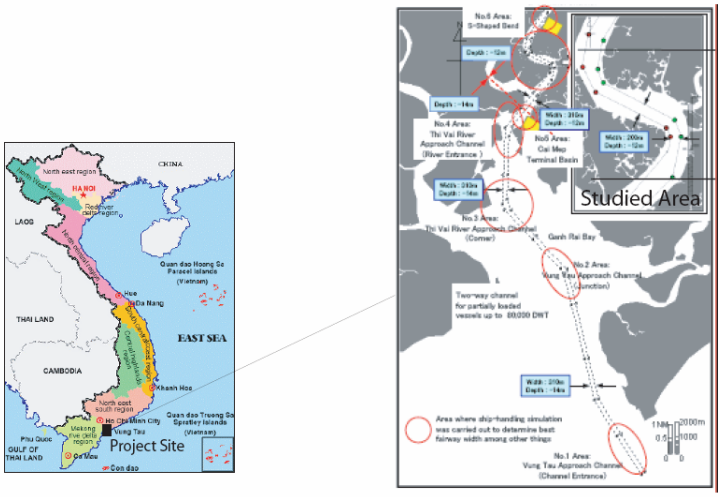

Figure 1: Project location and studied area

In recent years the following issues have arisen; the transport demand in this channel has been increasing, the size of vessels has become larger, the navigational speed has been increased and a need for reducing the waiting time of vessels has emerged. As a result, some projects to increase vessel traffic capacity of this channel have been implemented to meet the demand timely. Among of which the Rehabilitation Project of Thi Vai Channel for a ship of 70,000 DWT post Panamax-type container entering the Thi Vai International Port is the most important one.

2. METHODOLOGY

This paper, as a part of the above mentioned project, deals with the practical problem and the application of a ship-maneuvering simulator to the proposed widening design of the double bend part, so-called “S”-curve, of this channel.

2.1 PIANC recommendations

The numbers of real time simulation experiment were performed to obtain the data of the ship maneuvering characteristics. Probabilistic approach recommended by PIANC was used for the assessment of navigation risk. Probabilities of ship excursion of channel limits in several critical sections of the studied area for a certain channel width have been determined using the Gaussian distributions. Specific aspects of ship performance have been evaluated.

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2.2 Integrated method of navigational risk assessment

However, the risk considered for separate critical points of the channel only cannot be used for long-term optimal design of the channel width. As another component of this study, a method of integrated risk assessment for entire channel will therefore be presented.

Assuming that trajectories of ship track or swept path are considered as the response ensemble of non-stationary random processes, the method then concentrates on estimating time - dependent spectral density function, $S(\omega,t)$, on the basis of the response ensemble. Time - dependent spectral moments, $m_i(t)$, can be obtained (by integrating $\omega_i S(\omega,t)$ over all frequencies) and used to determine the time - dependent mean crossing rate $\nu(t)$. Finally, the extreme statistics of ship exceeding a level, b (cm), of the waterway limits during the period, T (sec), are determined using the so-called first passage problem.

It should be realized that the above approach for entire risk assessment is valid only if the exceeding level b are equally applied to all sections of the channel. For the problem under study, the width required in the curve is clearly higher than in the straight one because of the economic point of view. There is a possible solution that we consider all the sections as members in a series system and suppose they are equally correlated, the exceeding probability for the channel as whole can be defined as

$$P_g = 1 - \int_{-\infty}^{\infty} \prod_{i=1}^{n} \Phi\left[\frac{\sigma_i + \sqrt{\rho u}}{\sqrt{1-\rho}}\right] \varphi(u)\, du$$

where n is the number of sections; σ_i can be calculated from $\sigma_i = -\Phi^{-1}(P_i)$; Φ and φ' denote the standard Gaussian distribution and density functions, and ρ is the correlation coefficient; P_i is the exceeding probability in section i.

3. CONCLUSIONS

Since the risk of the entire channel can be assessed in an integrated manner, an optimal design of channel widths can be carried out. The method could also be useful for the evaluation of how much the mariner competence can be adapted to the navigation condition by exploring behavior of the power spectral density function of the manoeuvring results along the waterway.