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Simulation model of the LNG carrier with podded propulsion, Part II: Full model and experimental results

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ABSTRACT

The presented paper is the second part of the work devoted to the simulation model of the ship dynamics. The block oriented model was created and written as the S-function in the Matlab package and consists of the subsystems describing hydrodynamics forces, forces from two pods, two bow thrusters and wind. The values of all model parameters are also given. The results of the representative set of experiments preformed with the real vessel and its simulation model are shown at the last part of the paper. The attempt to estimate the model accuracy is presented at the end.

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1. Introduction

The multidimensional and strongly non-linear simulation models of the ship dynamics play a crucial role in the synthesis process of modern control systems for steering of the ship motion. Such models are used for example for building of multi-dimensional regulators – see Gierusz (2009) and Tomera (2012) and anti-collision systems – see e.g. Lisowski (2013).

The sea-going vessel like other moving objects can be treated as a rigid body with six quantities describing its movement: three linear velocities (surge – 'u', sway – 'v' and heave – 'w') and three angular velocities (roll – 'p', pitch – 'q' and yaw – 'r') – see Fig. 1. The simulation model which uses all velocities is commonly known as the model 6DOF (Degree Of Freedom). Taking into account fact that a merchant ship floats on the water surface – model 6DOF is not suitable and overly complicated.[1] Therefore simpler models 4DOF where pitch and heave are omitted and 3DOF without pitch, heave and roll velocities have more practical meaning.

The first nonlinear simulation model of the ship dynamics was devised in 1965 by Chislett and Strom-Tejsen for Mariner class vessel (Chislett and Strom-Tejsen, 1965). At present, several such models with the numerical values of the parameters for different types of ships were published[2]:

- model 3DOF ULCC tanker 'Sea Stratus' 350 m long (Kallstrom, 1979),
- model 3DOF VLCC tanker 'Esso' 305 m long (van Berlekom and Goddard, 1972),
- model 3DOF ULCC 'Esso Osaka' 325 m long (Bogdanov et al., 1987),
- model 4DOF ro-ro passenger 'Zenobia' 163 m long (Kallstrom and Ottoson, 1982),
- model 4DOF fast containership 175 m long (Fossen, 1994),
- model 4DOF ro-ro vessel 181 m long (Galbas, 1988),
- model 3DOF training ship VLCC tanker 'Blue Lady' 13.75 m long (Gierusz, 2001),
- model 3DOF training ship ferry 'Kolobrzeg' 11.0 m long (Gierusz, 1999).

The model presented here is 3DOF class due to a negligible influence of the waves on the lake on the ship movement. On the other hand the wind blowing across the lake strongly disturbs the

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[1] Such model is adequate for submarines or underwater robots – see e.g. Fossen (1994).

[2] Different simulation models of the ship dynamics are applied in widely used professional marine simulators but information about details of installed models are rather insufficient. Also many publications devoted such models occurred but they presented models without all values of the parameters – see e.g. Peiwen and Hui (2014) and Sutulo and Guedes Soares (2015).

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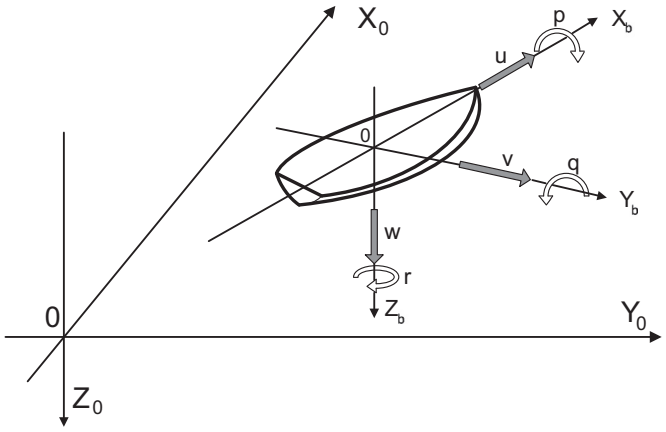

Fig. 1. The quantities describing ship motion: surge – 'u', sway – 'v', heave – 'w', roll – 'p', pitch – 'q' and yaw – 'r' with two commonly used reference frames: $X_0 - 0 - Y_0 - Z_0$ related to Earth and $X_b - 0 - Y_b - Z_b$ related to the ship.

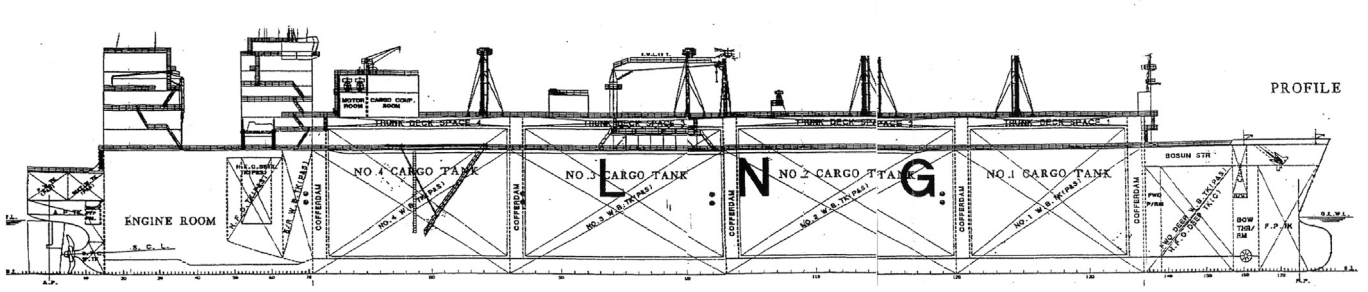

Fig. 2. The LNG carrier with capacity of 140 000 m^3 which was the original of the floating model.

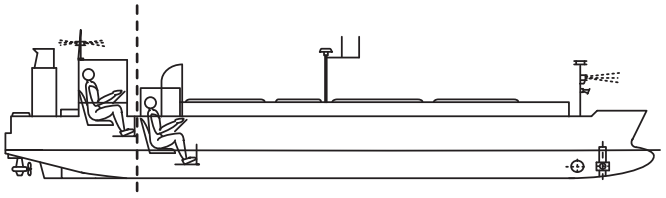

Fig. 3. The side view of the training ship "Dorchester Lady". The vertical dashed line marked the border between the hull and the removable stern.

Fig. 4. The ship "Dorchester Lady" on the lake Silm (in the front). The floating model of the passenger ferry "Stena Germanica" is seen at the back.

Table 1
The LNG carrier and its model.

Parameter	Unit	LNG carrier	Dorchester Lady
Length overall	L [m]	277.45	11.33
Breadth	B [m]	43.20	1.80
Draft	T [m]	14.00	0.50
Block coeff.	C_b [–]	0.79	0.79
Speed	V [kn]	15.70	3.20

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