Volume XXII 2019
ISSUE no.2
MBNA Publishing House Constanta 2019

Scientific Bulletin of Naval Academy

SBNA PAPER • OPEN ACCESS

Influence of trim and rudder angle on ship handling

To cite this article: Alecu Toma, Alexandru Stefan Bacioiu, Iulian-Adrian Chirita, Scientific Bulletin of Naval Academy, Vol. XXII 2019, pg.228-233.

ISSN: 2392-8956; ISSN-L: 1454-864X

doi: 10.21279/1454-864X-19-I2-027

INFLUENCE OF TRIM AND RUDDER ANGLE ON SHIP HANDLING

Alecu Toma[1]
Alexandru Stefan Bacioiu[2]
Iulian-Adrian Chirita[3]

1. Assistant Professor, Eng., PhD, „MirceacelBatran" Naval Academy, Constanta, Romania, alecu.toma@anmb.ro
2. MSc Student, Eng., „MirceacelBatran" Naval Academy, Constanta, Romania, bacioiu.alexandru@yahoo.com
3. Student, „MirceacelBatran" Naval Academy, Constanta, Romania

Abstract:The purpose of this paper is to identify the influence of trim and rudder angle on ship handling. Studying this matter using all available means, actual power rating at different trim values was put at comparison, also pressure diagrams and speed diagrams were taken into consideration. Upon completion of the paper, the actual power variation graph was plotted against the angle of trim.

***Keywords**: ship handling, trim, rudder angle, ansys, autopower*

INTRODUCTION

The ANSYS program was designed to be able to be used with an APDL parameter programming language (ANSYS Parametric Design Language). It allows the use of commands to generate the model in the program with finite elements in terms of some parameters (variables). Also, a number of results can be extracted through some parameters and used to get a number of functions required especially in the optimization module.

Almost all CFDs are based on the Navier-Stokes equations, derived from Newton's second law on fluid flow.

The exact numerical solution of the Navier-Stokes equations for turbulent flow is extremely demanding due to the wide range of time scales and dimensions involved in turbulent flow.

In order to simulate the process, the ANSYS-FLUENT program, which deals with the fluid flow study, was called for.

Consider the body of the ship floating in a parallelepiped body with a sea water density of 1025. In the next figure are presented the flow directions.

The body volume in water is 6085 m3 and the surface area of the 4750.4 m2, with 15 surfaces and 37 angles.

Details of Body	
Body	Solid
Volume	6085 m^3
Surface Area	4750.4 m^2
Faces	15
Edges	37
Vertices	24
Fluid/Solid	Solid
Shared Topology Method	Automatic
Geometry Type	DesignModeler

Figure 1.The constructive dimensions of the body

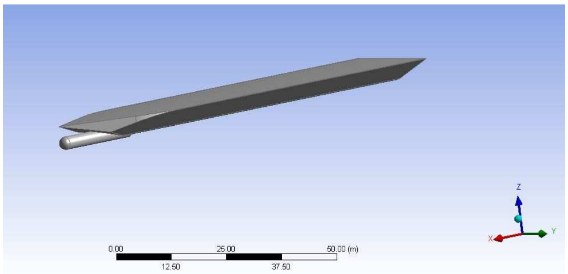

Figure 2.Presentation of the analyzed model

In the above figure is presented the body model of the ship made with the functions of the program.

PROFILE MESHING

At this stage, we have meshed the reservoir. The higher the number of cells, the more laborious the calculation of the parameters and it takes a longer time. We meshed the model previously created using refining functions as in Figure 3.

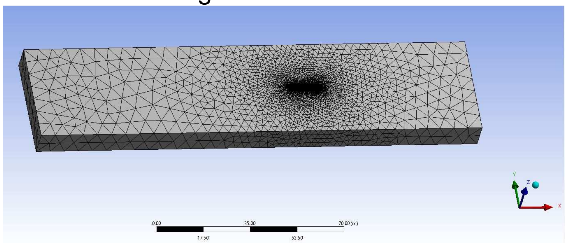

Figure 3.The final meshed model.

The meshed structure has 61713 nodes and 350327 components.

PRESENTATION OF SIMULATION RESULTS AT DIFFERENT SPEEDS

Results pressures and speeds around the hull for different angle of trim are given in the figures below.

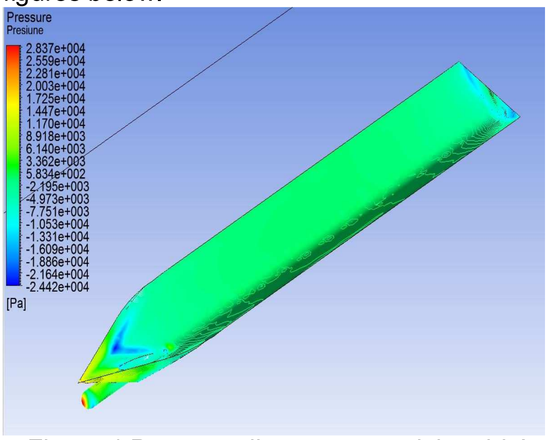

Figure 4.Pressure diagram around the ship's body at 0° trim

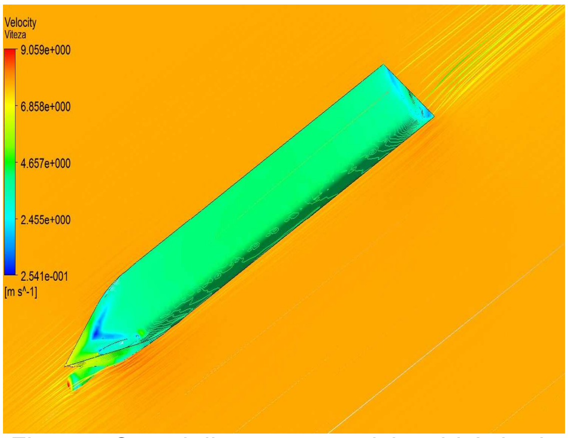

Figure 5.Speed diagram around the ship's body at 0° trim

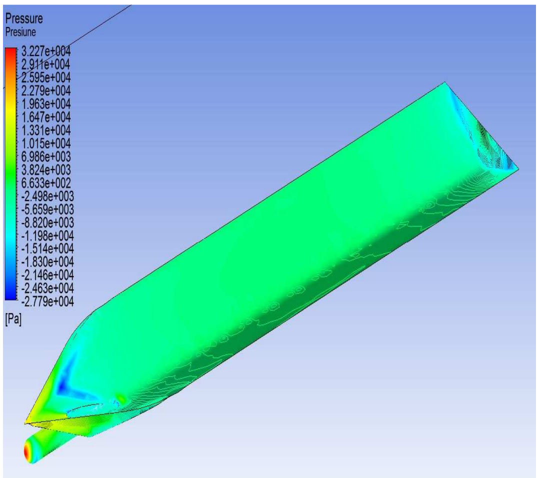

Figure 6.Pressure diagram around the ship's body at 2° trim

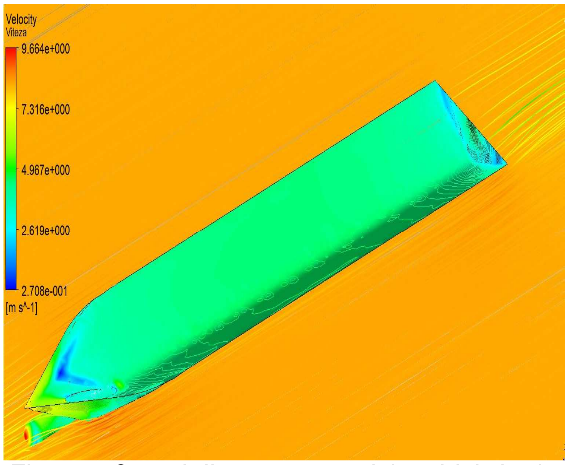

Figure 7.Speed diagram around the ship's body at 2° trim

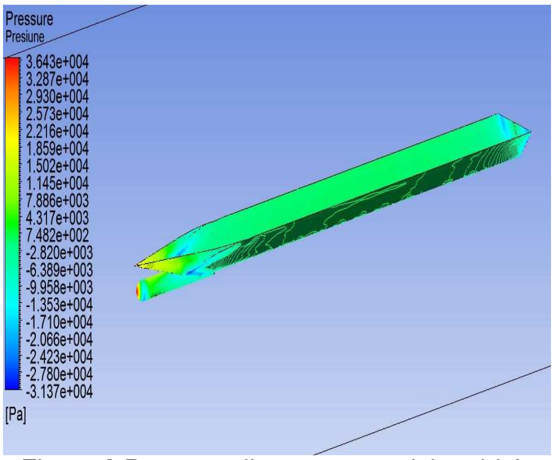

Figure 8.Pressure diagram around the ship's body at 4° trim

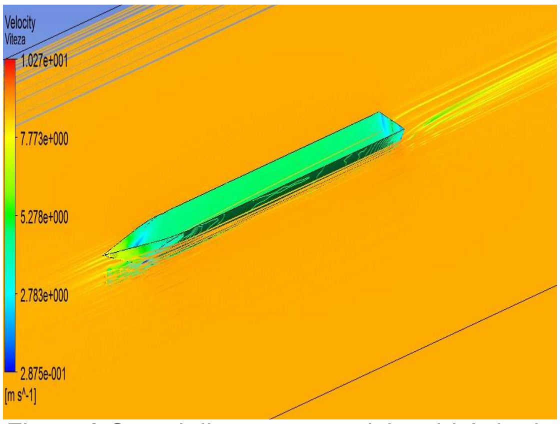

Figure 9.Speed diagram around the ship's body at 4° trim

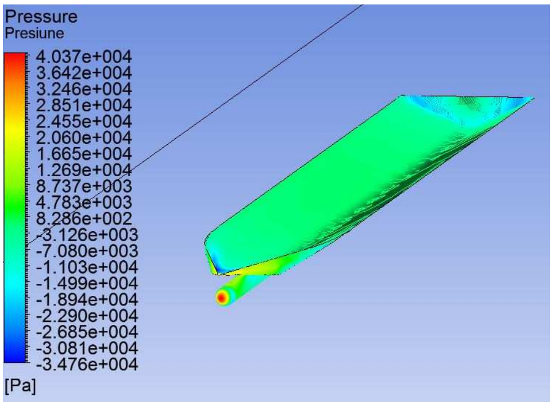

Figure 10.Pressure diagram around the ship's body at 6° trim

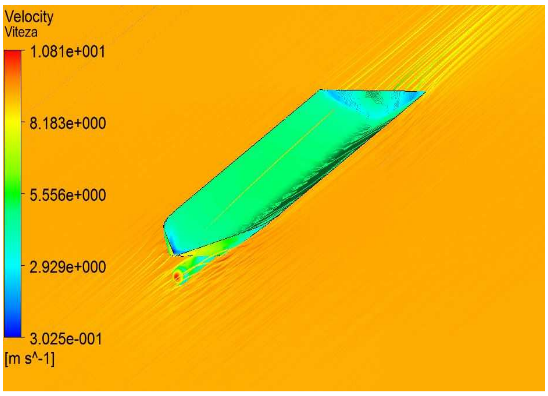

Figure 11.Speed diagram around the ship's body at 6° trim

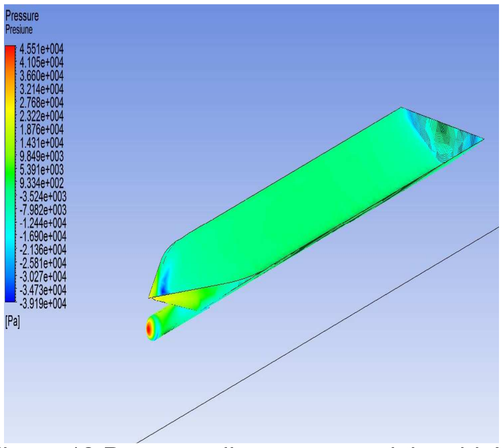

Figure 12.Pressure diagram around the ship's body at 8° trim

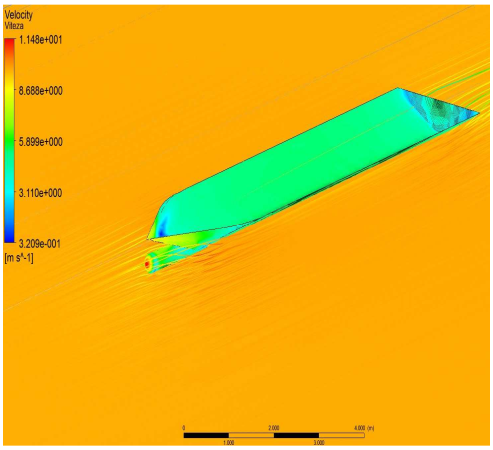

Figure 13.Speed diagram around the ship's body at 8° trim

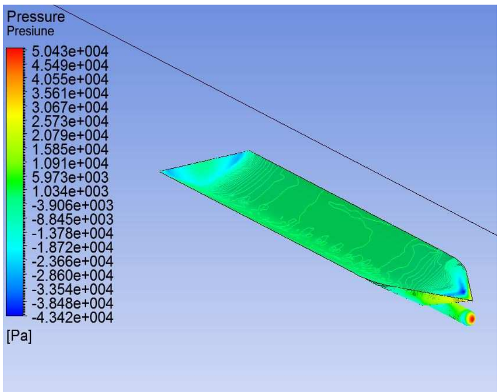

Figure 14.Pressure diagram around the ship's body at 10° trim

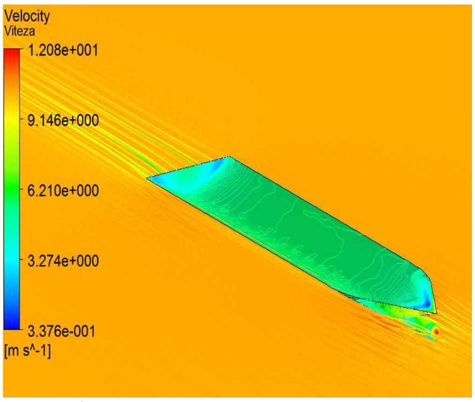

Figure 15.Speed diagram around the ship's body at 10° trim

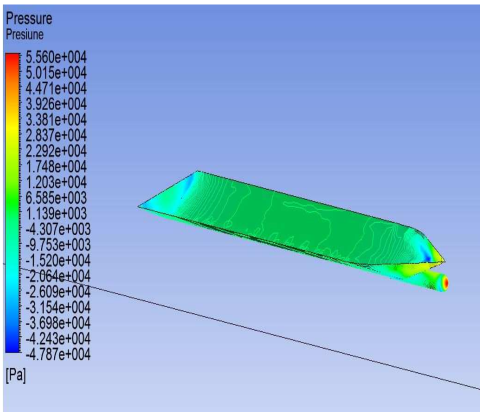

Figure 16.Pressure diagram around the ship's body at 12° trim

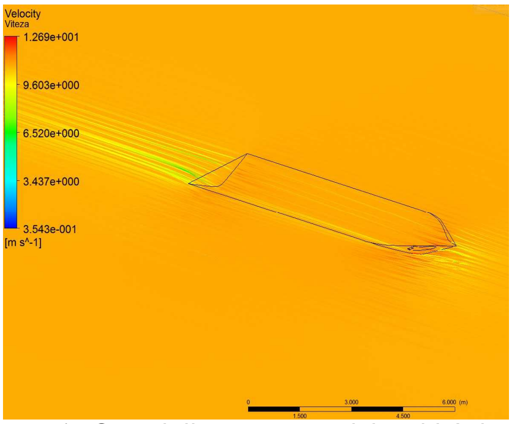

Figure 17.Speed diagram around the ship's body at 12° trim

CENTRALIZING THE RESULTS

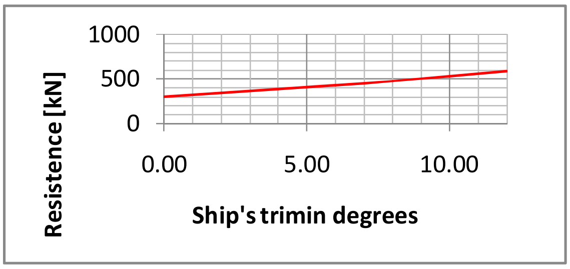

Figure 18.Presentation of variation of real ship resistance based on trim

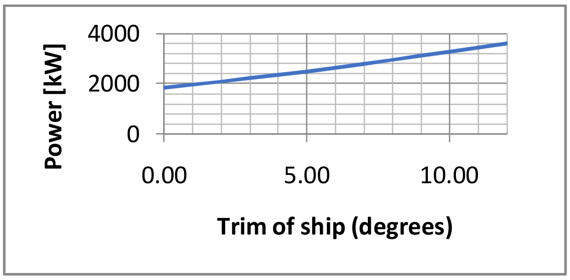

Figure 19.Presentation of propulsion power variation according to trim

INFLUENCE OF TRIM ON SHIP HANDLING

In order to make the calculation, the ship shall be deemed to have trim by the bow or by the stern at an angle of 0 to 5 °. Thus, with these values, the draft and the draft difference will be calculated by applying the formula:

$$tg\alpha = \frac{\Delta T}{L_{pp}/2}$$

where: ΔT - the difference in draft between the aft and the bow.

Lpp = 84.94 m length between ship's perpendicular.

This will result in the spreadsheet calculation table:

Table 1.Calculation values for drafts

α	$tg\alpha$	ΔT[m]	T_{pp}[m]	T_{pv}[m]
0	0	0	5,68	5,68
1	0,01745	0,7413	6,4213	4,938
2	0,0349	1,483	7,163	4,197
3	0,0524	2,225	7,905	3,423
4	0,0699	2,969	8,649	2,711
5	0,0874	3,71	-	-

The case of the vessel is similar to the inverted drafts. The case of 5 degrees of the angle of the cut leads to a value of the very large draft difference which will give a draft greater than the ship's height of construction. The angle of 4 degrees will result in a value of 8,649 m.

For the calculation, the Autopower program was used for which the Naval Academy holds an operating license. This program helps us calculate the drag resistance for different fishfing according to the table above. The following steps will be followed in making the calculation.

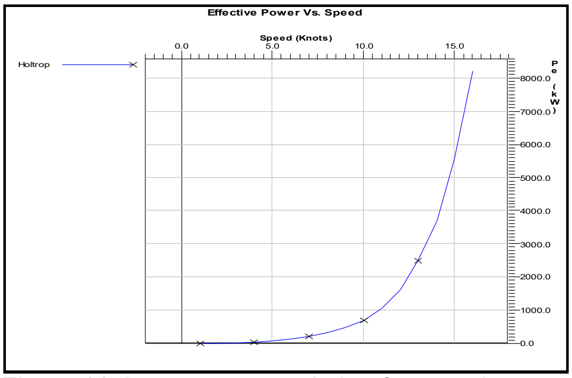

Figure 20.Actual power variation for even keel

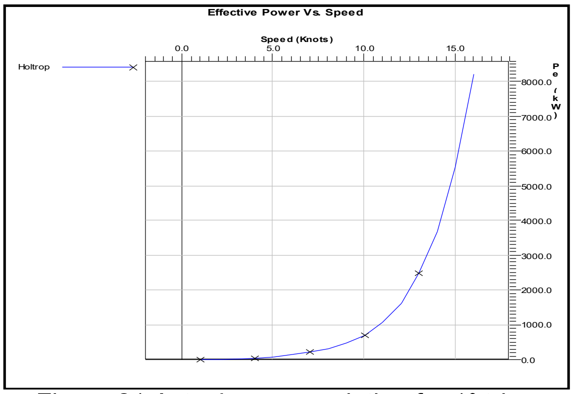

Figure 21.Actual power variation for 1° trim

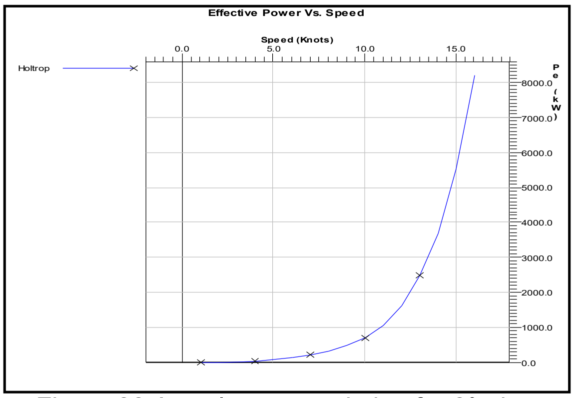

Figure 22.Actual power variation for 2° trim

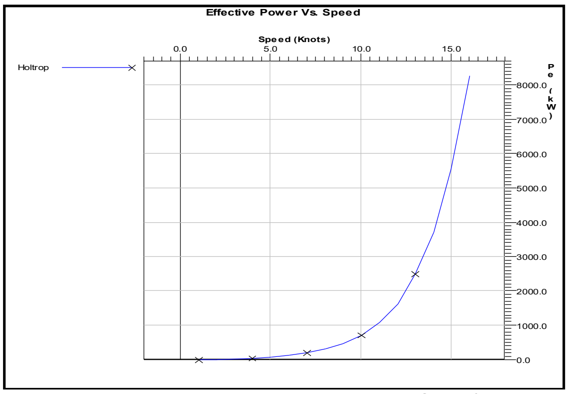

Figure 23.Actual power variation for 3°trim

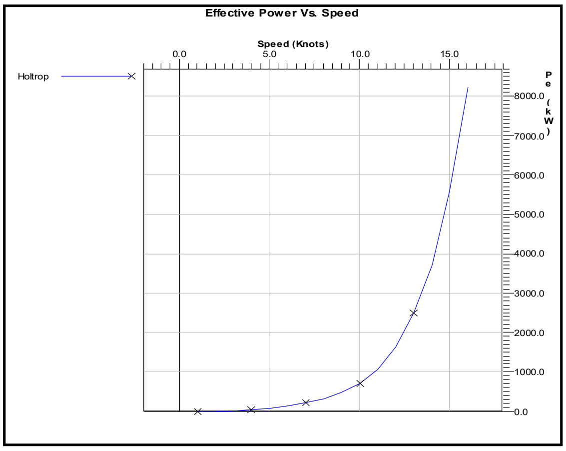

Figure 24.Actual power variation for 3°trim

After centralizing the results, the actual power variation graph will be plotted against the angle of trim.

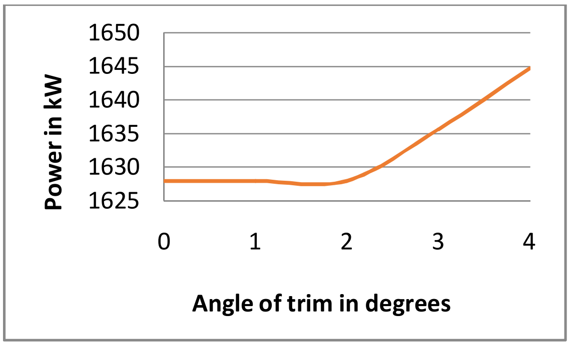

Figure 25.Variation of power for the case when the ship have trim by stern

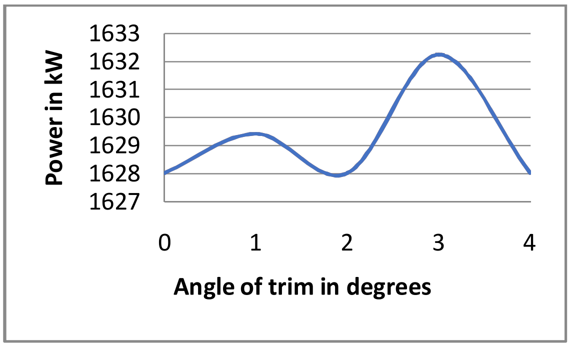

Figure 26.Variation of power for the case when the ship have trim by head

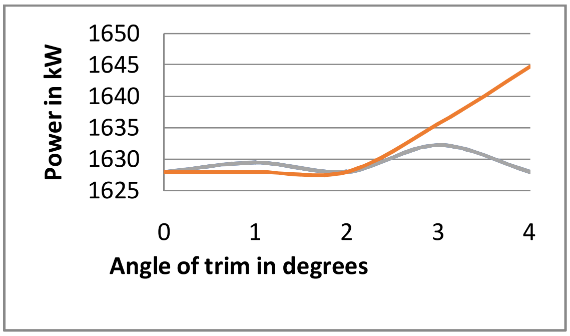

Figure 27.Comparative presentation of the two

As can be seen only in the case of trimmed by stern ship, it can be considered a rule, the power increases with increasing the power of the trim angle. The 5-degree angle values were not calculated due to the fact that the value of the draft exceeded significantly the value of the ship's construction width.

Bibliography:

[1] C.B. Barrass, Captain D.R. Derret; Combined listed and trim; Vol. 20; 2006; pg. 98-201;

[2] M. Ueno, Y. Yoshimura, Y. Tsukada, H. Miyazaki; Circular motion tests and uncertainty analysis for ships maneuverability; Vol. 1; 2009; pg. 470-484;

[3] S. Haik, S.D. Ross; Geometry of escaping dynamics in nonlinear ship motion; Vol 47; 2017; pg 48-70;